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OF THE

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

1913.

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ELECTRICAL ENGINEERING

WITH WHICH IS INCORPORATED

THE ELECTRICAL ENGINEER

(Established 1884)

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PROCEEDINGS

OF THE

EIGHTEENTH ANNUAL CONVENTION

OF THE

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION,

LONDON and KINGSTON-UPON-THAMES,

June 17th to June 21st, 1913.

REPORTED BY ARRANGEMENT WITH "ELECTRICAL ENGINEERING."

TUESDAY, JUNE 17th.

MEETING AT THE INSTITUTION OF ELECTRICAL ENGINEERS.

The Association met at 10 a.m., and was welcomed by Mr. W. Duddell, F.R.S., President of the Institution of Electrical Engineers.

Mr. Duddell said it gave him the greatest possible pleasure to welcome the Association to the new building of the Institution of Electrical Engineers, on behalf of the Council of that body. Looking back a little at the history of the Incorporated Municipal Electrical Association, he said that when it started in 1896 it was a very small body, and one criticism that was put up against it in the Press at that time was that it was hasty in its meetings; that it hurried

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too much. He believed, however, that it had now grown up, and that the Association took itself very seriously. In fact, looking back at the proceedings of the last few Conventions, it seemed that it had considered very seriously all the important subjects which affected the electrical industry. Things were progressing, and he noticed that on the programme for this Convention, also, were some of the most important subjects which were exercising the minds of electrical engineers. His wish was that the deliberations at the Convention would lead to good results, and that any results come to would be for the welfare of the industry as a whole, because although it was really an Association of Municipal bodies, the members would agree that the welfare of the whole electrical industry was the main thing to work for, and he was quite certain that in working for the industry as a whole they would be promoting at the same time the welfare of the particular branch in which they were interested.

The President (Mr. J. E. Edgcome, Chief Electrical Engineer, Kingston-upon-Thames) thanked Mr. Duddell for his welcome on behalf of the Institution of Electrical Engineers. They were, most of them, and they all ought to be members of the Institution of Electrical Engineers, which was the senior body, and they must feel that in coming to this building they were more or less coming home. If he might be allowed to congratulate the Institution, through Mr. Duddell, it would be on the formation of the Industrial Committee, which, under the able chairmanship of Mr. Hugo Hirst, was doing, and would continue to do, very good work for every branch of the profession.

Continuing, Mr. Edgcome explained why it was that he was not delivering a Presidential Address. Members, he said, had naturally looked forward to being presided over by Mr. Shawfield, who was unanimously elected last year to the position of President, but in giving up his position as Chief Electrical Engineer at Wolverhampton, Mr. Shawfield had been obliged to give up his position as a member of the Association. The Council had then decided to elect for the remainder of the term a Past-President, and the choice had

fallen on him (Mr. Edgcome). He had felt, however, that the members were still entitled to receive a Presidential Address from Mr. Shawfield, especially as he himself had already given a Presidential Address seven years ago. Although Mr. Shawfield had been obliged to give up his connection with the Association upon leaving municipal work, he hoped that at no very distant date they would be able to bring him amongst them again as an Honorary Member.

There were two other points upon which he would like to touch, the first being in the nature of an apology, and the second in the nature of a protest. In his Presidential Address seven years ago he had expressed the hope that at no distant date the Association would start an Information Bureau. But when he vacated the Chair he had been elected Honorary Treasurer, and he was afraid that the enthusiasm of the President had since been somewhat damped by the financial caution of the Treasurer. Consequently, the matter must be delayed until they found some means of increasing their revenue. He would suggest that such a means would be found in a sliding scale of subscriptions or donations from the larger municipalities. At the present time all municipalities, large and small, paid a practically nominal subscription, but it seemed to him that it would be fair that the larger undertakings should pay a larger subscription *pro rata*, either upon capital expenditure or profits.

The second matter, as he had said, was in the nature of a protest. Lately several municipalities had thought it wise to include an age-limit restriction when appointing engineers and managers of their undertakings, and he would like to point out strongly that no possibly good purpose could be served by this. The fact that there was no such restriction would not in any way tie the hands of a municipality when making the selection of their engineer, and they would be able to select suitable men of any age they thought fit. He considered that in these days, when the Chief Engineer and Manager of a big undertaking had to have experience, not only on the engineering side of the profession, but also on the commercial side, a man who had already had very

considerable experience in the generation and distribution of light and power, with all its many and varying responsibilities, must be better fitted to take charge of a large undertaking than a younger man, who, from his age, had not had time to get that experience. He was not at all in favour of the view that a man is " too old at forty."

As Mr. Shawfield was unable to be present, Mr. Edgcome read his Address, as follows :

Incorporated Municipal Electrical Association

CONVENTION, LONDON, JUNE, 1913.

Address

OF

MR. C. E. C. SHAWFIELD,

Ex-President, late Chief Electrical Engineer to the Corporation of Wolverhampton.

THE position of President of the Incorporated Municipal Electrical Association is undoubtedly one which carries with it many and varied responsibilities, and those Members of your Association who have passed the Chair, will doubtless agree with me when I venture the opinion that the preparation of the Presidential Address is by no means the least of these responsibilities. Nevertheless, I feel that an even greater burden rests upon my shoulders in having somewhat rashly acceded to the expressed desire of your Executive Council that I should prepare an address to be read at the opening of your 18th Annual Convention. It is, I believe, the first time in the history of your Association that the opening address at the

Annual Convention has been given by other than the President for the time being, and whilst I deeply appreciate the compliment which your Council have paid me, I must confess that I approach the task with a good deal of apprehension.

First of all I desire to express to you my very sincere thanks for the honour you did me when you elected me your President twelve months ago. This is the highest office which you, as an Association, have in your power to bestow, and it was with very real regret that I found myself compelled to lay down the reins of office, owing to my vacating Municipal Service.

At the time of the formation of the Municipal Electrical Association in 1895, electricity supply was truly in its infancy, and like most infants, progressed with somewhat weak and faltering steps. In what was quite a large central power station in those days there would often be found a neatly arranged row of generating sets of sizes ranging from 10 k.w. to deal with the day load, up to monsters of 50 or even 100 k.w. designed to cope with the peak load, which occurred during a few evenings in December. At that time absolute continuity of supply was a dream seldom realised, and there were few householders or shopkeepers who did not keep a supply of candles and matches in readiness for the expected breakdown.

It is difficult to realise that in the eighteen years which have elapsed since the first meeting of your Association was held in London, the electricity supply infant has grown into such a remarkably well developed and healthy adult, and that it is now surrounded by a numerous and healthy progeny of allied industries and undertakings.

One of the most remarkable features in connection with the growth of electricity supply during recent years, is the enormous increase which has taken place in the application of electricity to industrial purposes, and the rapidity with which its status has changed from being that of a luxury

to be enjoyed by the few, to that of a necessity which is demanded by the many. A cheap supply of electricity is now as necessary to the welfare of the community as a whole, as is a cheap and ample supply of water, or the provision of a well-designed system of drainage.

There can be no doubt that the rapidly increasing use of electricity by manufacturers for motive power purposes has had a marked effect in improving and purifying the atmosphere of our large industrial centres, and this will doubtless have been brought to the notice of many Members of this Association by the decreasing frequency of the fogs, upon which many of us formerly depended for the improvement of our lighting load factor.

When reviewing the present position of public electricity supply in Great Britain and the progress that has been made since its inception, one is struck by the fact that so far as the provinces are concerned, the great bulk of the industry is under municipal control, and the question immediately arises—has the progress that has been made, been in spite of, or because of, municipal ownership? As in most matters of policy in this country, public opinion appears to be sharply divided upon this question, and whilst one section asserts that municipal control is essential to the proper regulation of the supply of public necessities, another party as loudly condemns it as being economically unsound. I must confess that after seventeen years of municipal work, I am unable to give my adherence to either of these opinions, because although it is perfectly true that in certain instances electricity supply has languished whilst under Local Government administration, there are other instances where magnificent results have been achieved, second to none that have been shown by any private enterprise. Moreover, it must be remembered that in certain cases the opponents of municipal trading have done their best to thwart and hinder those who were endeavouring to develop municipally owned undertakings on business lines, and when their efforts have been partially or wholly successful, they have pointed the finger of scorn at their victims and held them up as typical illustrations of municipal mismanagement.

It must be borne in mind that during the early years of electricity supply, the establishment of a central station in many of our provincial towns would probably not have been possible, except for the fact that municipalities were able to raise capital at relatively low rates of interest, and the fact that a large number of small stations have been provided and operated by municipalities under conditions that no private company could have survived, has resulted in a vast amount of valuable experience having been obtained in the design and arrangement of generating plant and distributing systems, of which we are now beginning to reap the benefit.

Much has been said for and against the principle of municipal trading in the past, and I have no desire to add further to what is too frequently a profitless discussion. The fact remains, however, that whether for good or for evil, Parliament has committed to the municipalities of this country the control of the supply of electricity to the bulk of the community, and it rests with the members of the Incorporated Municipal Electrical Association to see that this trust is not misplaced.

One of the most curious anomalies of the present position of the public supply of electricity in this country is, that whilst a municipality is empowered to generate and distribute electricity throughout its area, and to make contracts with consumers as to the terms and conditions of supply, it is practically debarred from installing in a consumers' premises the apparatus which is necessary to enable that consumer to utilise the electricity which the municipality has for sale. That is to say, that whilst a local authority is permitted, and even encouraged, to spend tens of thousands in generating plant and distributing mains, it is not permitted to spend tens or hundreds in the purchase and installation of wiring, fittings and motors. You are told that this restriction is placed upon you because if you entered into the business of supplying fittings and installations, you would be competing with private enterprise, and that you have no right to use money borrowed on the

security of the rates to finance a retail trading department. The supporters of this theory apparently ignore the fact that the existence of an electric supply undertaking postulates the provision of means to enable the electricity to be consumed. In London, and in a few of the larger provincial towns, this necessity can be, and is, to a large extent provided by private enterprise, but many of you who are associated with stations in smaller communities, know only too well that the average wiring contractor has not the capital or the staff, and too frequently also, has not the ability, to adequately supply the requirements of consumers. It is true that some municipalities have been fortunate enough to obtain, by means of private acts, full powers to carry out wiring and installation work of all descriptions and to sell and fix electricity consuming devices. The Corporation of Wolverhampton has possessed these powers since 1899, and after fourteen years' experience of the practical operation of these powers, I can unhesitatingly affirm that both the Electricity Department and the local wiring contractors are in a flourishing condition. If a municipality has only the restricted powers given under the Electric Lighting Clause Amendment Act—by which wiring work can only be carried out through a contractor—the result is of very little use to either party.

I sincerely trust that this Association and the municipalities which it represents will continue to press for the general concession of those powers to all municipalities, which are at present confined to a section only.

I am entirely opposed to what I regard as the vicious practice of rate relief from the profits of electricity undertakings, and I sincerely trust that the Members of this Association will do whatever lies in their power to discountenance these donations. This subject was exhaustively dealt with by one of your past Presidents about two years ago, and I can only express my heartfelt concurrence with his expressions of opinion. I would go further and say that whilst municipally owned electricity undertakings should be self-supporting, their surplus earnings should be allocated,

firstly to the accumulation of an adequate reserve fund, secondly to the provision of working capital, and that any balance remaining should be devoted to the extension and improvement of the undertaking.

It has frequently been stated by one of the Inspectors of the Local Government Board that to borrow capital for extensions with one hand whilst giving surplus profits to the relief of rates with the other, is virtually equivalent to borrowing money for purposes of rate relief. I cannot help agreeing with him on this point.

Much has been done in recent years in the direction of lowering the average rate of charge per unit to all classes of consumers, but I firmly believe that much still remains to be done in this direction, and that if municipally owned electricity undertakings as a body were to go boldly for a drastic reduction in prices, they would not only be more faithfully performing their duties to the community as a whole, but they would also reap a rich reward in the shape of increased output and better financial results. As a general principle I believe that practically every central station can afford to sell electricity at a profit, at a lower price than that at which none but a specially circumstanced private generating plant can produce it, and it should be the aim of every undertaking to supply from its mains every unit of electricity consumed within its area. There is a great temptation to enlarge upon this question, but as I have already inflicted upon you one paper on this subject, I must not trouble you further.

Up to the present the history of electricity supply in this country has been one of constant warfare against gas competition, both for lighting, heating and motive power, and it may now be safely affirmed that electricity has won for itself an assured and unassailable position as regards public and private lighting and for motive power purposes, whilst it is making a strong attack upon the hitherto impregnable position of heating and cooking.

The time is now rapidly approaching when a large part of the present capital liabilities of electricity undertakings will be liquidated by the operation of the Sinking Fund, and when this day arrives, it seems probable that such a general reduction in the selling price of electricity will be possible that its practically universal adoption for lighting and motive power purposes will become inevitable.

Hitherto, the competition between electricity and gas has been beneficial both to the competitors and to their consumers, but I have thought that the time may arrive when it may be to the interests of both parties, and of the community generally, that instead of competition, there should be co-operation, the suppliers of gas devoting their energies to the economical production of non-illuminating producer gas, which could be used by the suppliers of electricity for the production of electrical energy. If such an arrangement were possible, it would assist in the husbanding of our coal resources and would bring a little nearer that flat rate of something less than one halfpenny per unit which at present seems rather a Utopian vision.

The question of the management of electricity undertakings, especially as affecting the relations between the Electricity Committee and their responsible officials, is a rather delicate subject and is usually more suitable for discussion in camera than for an address of this description. The success or failure of any undertaking depends in no small measure upon the degree of confidence which the Committee reposes in their Chief Engineer and Manager, and I would most respectfully urge that the Chief Engineer of every electricity undertaking should be given full control, not only of the technical, but also of the financial side of his department, subject of course to the strictest audit by the Accountants Department and the public auditors. He should have complete control of the general staff of the department, and all matters of discipline and of the remuneration of employees should be left to his discretion. He should also be provided with a competent and well-paid technical staff. I am afraid that in too many cases (some

of which I am personally acquainted with) the rates of pay of the technical assistants in some of our large undertakings are entirely inadequate to their duties and responsibilities. The best asset that any electricity undertaking can possess is a loyal and zealous staff, who have at heart the commercial and technical well-being of the concern, and in order to secure this, it is necessary that every member of the staff of every grade shall be made to feel that he is a trusted and responsible official, and that he is adequately remunerated for his services.

Conclusion.

In conclusion, I particularly wish to express my appreciation of the real benefit which accrues from membership of the I.M.E.A. The actual work done by the Association through its Executive Council is of the greatest importance to the electric supply industry as a whole, but of even greater benefit than this is the good feeling which is promoted amongst the component members of the Association. It is a surprising, but nevertheless pleasing fact that any member can practically call upon the experience and resources of the whole of the rest of the members in case of any difficulty which he may encounter, and any assistance that he may ask for is given with the utmost freedom and willingness.

I have been a Member of the Association since shortly after its formation and have had the privilege of being a Member of the Executive Council for the last seven or eight years, and I much regret that the fact of my leaving municipal work involves my leaving also the I.M.E.A.

I particularly desire to thank the Members of the Executive Council and the Officers of the Association for their loyal co-operation and support during my brief term of office as President, and to express my sincere hope that I shall frequently have the opportunity of renewing the many friendships which I have formed amongst you.

A vote of thanks having been accorded to Mr. Shawfield for the Address, the following paper was read: "Prime Movers for Electric Power," by Dr. S. Z. de Ferranti.

Prime Movers for Electric Power.

By Dr. S. Z. DE FERRANTI,

Past President, I.E.E.

NOTWITHSTANDING the amount that has been written regarding the different systems of driving electric generators, the subject still seems to be one of considerable interest.

The position to-day is that the steam turbine is in possession of the field, and that gas and oil engines are looked upon as likely alternatives.

Many people believe that it is only prejudice or the fear of doing something new that prevents engineers from using these two latter methods for generating their power.

I do not, however, agree with this view, and believe that engineers are using the only means that are at present economically available for the work they have to do.

Electricity is being produced on a larger scale every day, and it appears certain that to obtain the full benefits of electric working the current must be produced in large stations supplying extensive areas embracing all classes of demand.

As we are dealing with prime movers for electric power, I will, therefore, consider the question from the point of view of the comparatively large generating station. The essential qualities of a power producing plant are reliability and low cost as regards capital running and maintenance.

The question before us may be considered in detail under the following headings :—

(1) Nature of fuel consumed, its availability and cost.
(2) Amount of fuel consumed per unit generated.
(3) Standbye losses.
(4) Labour involved in running.
(5) Cost of upkeep of plant.
(6) Capital cost of plant.
(7) Size of units, simplicity or complication.
(8) Reliability and proved capacity for work required.

As we are a coal producing country it is evident that coal is our natural fuel. The very fact of oil being so sought after as fuel for certain purposes puts it out of the question for general power production.

In the first place, the automobile on land must consume and even now consumes large quantities of light oil.

For the Navy oil is so eminently suitable as fuel that the demand in this direction will always raise its price above that due to its heat value.

Furthermore, if there is ever a surplus after supplying the Navy, there remains the vast and ever increasing demand by the Mercantile Marine who will always be able to pay more for it than land consumers could do.

It is, therefore, clear that coal must be our fuel where operations are carried on on a large scale. In the future, the oil consumers above mentioned will even be partly supplied from the bye-products of our coal, instead of our burning any appreciable amount of oil for making electricity.

It is, therefore, vital that our power producing plant should be coal burning. The plant must be made suitable for the fuel, and not fuel found to suit a particular form of machinery.

We have next to consider the thermal efficiency of the plant for producing electricity. By this I mean the percentage of the heat in the fuel turned into current.

A good steam turbine and boiler plant will to-day give back 15 per cent. of the energy of the fuel as electricity. As high an efficiency as 18½ per cent. has actually been obtained in practice.

It is probable, however, that this is by no means the limit of economy and that developments in this class of machinery will result in an efficiency of 25 per cent. being obtained in the near future.

The next coal burning machine that we have to consider is the gas engine. With it we have to consider not only the efficiency of the machine itself, but also that of the gas producing plant.

When the system is considered from this point of view its efficiency is probably between 20 per cent. and 22 per cent.

With this process there should, of course, be worked bye-product recovery. Although it appears evident that in the future all coal must be gasified and its bye-products recovered, it does not seem that present knowledge enables this to be done at sufficient profit for it to be generally adopted.

In the oil engine we have a machine which represents the highest efficiency yet realised. Moreover, test figures and those obtained in practice agree very closely.

The efficiency as already defined may be taken at between 28 per cent. and 30 per cent.

The question of standbye losses may next be considered. In the oil engine there is practically no loss under this heading.

In the gas engine there is the producer loss, and in the turbine the boiler loss. These will vary very much with the nature of the load, and where the plant is well designed and run and the load factor is good they may be reduced to a small quantity. Both the oil engine and the gas engine are,

however, badly handicapped in relation to the steam turbine by their incapacity for dealing with overloads which the station must always be in a position to meet.

With regard to the question of the labour involved in running and maintaining the plant ; as matters stand to-day the turbine installation is undoubtedly the best, but it is hard to make a direct comparison as the number of generating units with either gas or oil would be so great. It is, however, certain that the plant which is the simplest will always have the advantage, and where one is purely rotary and the other reciprocating there can be no question at all.

In the matter of capital cost the turbine system is again much the best, the simplicity, large units and small space occupied contributing to this result. The size of the units on the turbine system compared with those on the other systems is perhaps the greatest determining factor in the case. The turbine is to-day adequate in fulfilling the demand, whereas the other two systems are not. Moreover, combined with its boilers and auxiliary plant, it is a simple means of generating power.

Reliability of operation is, of course, vital, and here again the turbine system scores on account of its great simplicity and because in working its parts are not subjected to either high or uncertain stresses.

In practice the turbine system has proved its capacity to meet the demand that is made on power producing plant. All this goes to show that the course now followed by engineers in the selection of their plant is the right one, and that they really have no option in the matter.

Looking at the question in the light of possible developments of the future, I cannot help thinking that as long as engines are used the rotary principle will be followed. For the moment the steam turbine system will be perfected so as to improve its efficiency and fuel consumption ; later on, when the turbine can be made of the internal combustion type better economies still will be obtained.

DISCUSSION.

Colonel Sinclair (Chairman, Swansea Electricity Committee) agreed with the conclusions in the paper in so far as they related to very large units and very large power stations. Dr. Ferranti, he said, had sketched a possible electrical millennium such as the standardization of all machinery, etc., and the linking up of all areas, but until that time arrived—and he thought it was far away off yet—there would still be power stations in connection with individual works, and even for small towns, and perhaps for the linking up of small hamlets, where the reciprocating engine would still have a look in, and it was upon this point that he wished to speak. Pioneering was always interesting, but it was sometimes dangerous, although he could not himself complain with regard to the latter. As far back as 1885 he had the audacity to order two 50 k.w. continuous current machines which were the largest of that type then in use, and incidentally he might mention that they were still running and giving very fair satisfaction. More recently his people had had occasion to instal a reciprocating engine of a comparatively new type for works driving, that known as the unflow engine, made under Professor Stumpf's patent. This had only two valves and was a single cylinder engine with no exhaust valves, the piston in moving from end to end uncovering a number of circular holes in the periphery of the cylinder and allowing the steam to pass to exhaust. In all other respects it was very similar to any other reciprocating engine. He had two of these connected to 300 k.w. continuous current generators with a booster and a 1,000 ampère-hour battery. The motors used varied from ½ h.p. to 500 h.p. The manufacturers on tests of these engines, got well within their guarantee of slightly under 9 lbs. steam per i.h.p. with a 170 lbs. pressure and 225 degrees superheat. His own opinion, however, was that it was wiser to go upon test figures for a long period, and he was able to give figures of this sort. These engines had now been running for two years, and the latest result was that after a continuous year's working, one of these machines generated 1½ million units, the load factor was 44½ per cent., and the coal used per unit 3·26 lbs. The operating costs were: wages 0·0934; coal, 0·202; material, 0·0244; repairs, 0·0291; making a total of 0·3489 per unit. The coal used was 13,500 B.Th.U., and the average pressure 165 lbs., and the average superheat 200 degrees. He did not claim anything marvellous in these figures, but from the point of view he had given them, he hoped anyone criticising them would bear in mind the point that during the coal strike for five weeks his machines ran with a load

of only 25 per cent. the whole time and that, of course, did not tend to excessive economy. Included in the figures also was a large amount of experimental work, the units for which were not metered. The load on the plant varied from 150 to 800 k.w., the battery taking the peaks. He hoped he had made a case for reciprocating engines for small stations.

Mr. G. D. Seaton (Messrs. Richardsons, Westgarth & Co., Ltd.) said he always listened with great interest to Dr. Ferranti whose grievance against municipal electrical engineers, some years ago at least, was that they hindered progress by accepting the lowest tender, although in the present paper he did not include this in one of his eight points. Why was it that municipal electrical engineers accepted the lowest tender ? People who had no previous experience in steam turbines had his deepest sympathy, and as things were at present, it was almost impossible for them to avoid accepting the lowest tender. How was the ordinary person to get to know all that those who were daily engaged in the business knew ? Supposing, for example, a man was in the market for a 2,000 k.w. alternator. He would put in the usual advertisements in which it was definitely stated " We do not bind ourselves to accept the lowest or any tender," although of course they did in nine cases out of ten. In reply to such an advertisement there would be about ten offers, and for a week the engineer was busy laboriously scheduling these tenders and probably there might be two or three alternatives to each. Probably it would be found that the only way in which the machines varied from one another was in the matter of price, and this variation on a 2,000 k.w. machine might be from £600 to £800 between the highest and lowest tender. It was quite as likely as not that it would be found that the lowest steam consumption would be associated with the lowest price, and of course the engineer naturally wondered why he should not accept that tender. If he made a few enquiries he would get the usual stereotyped replies, and what was the man to do but to accept the lowest tender. The whole thing rested on the question of tests. The Borough Electrical Engineer would decide to have a test made, but what did this test consist of ? It was about the most Gilbertian and most incomprehensible thing that he could possibly imagine, for the Engineer simply let the makers test their own machines. He was aware that the Engineer supervised the tests ; but his advice was that if they wished to hasten the millennium which Dr. Ferranti had referred to, they should buy their plant on merit and have it tested independently, and further, they should publish these tests. He

would entrust the test to the Company to which Mr. Michael Longridge belonged, because the tests carried out by Mr. Longridge which he had seen were very different affairs from some so-called municipal tests which had come under his observation. If this were done, there would be a very strong encouragement to do even better than the 18½ per cent. out of the coal to which Dr. Ferranti had called attention.

Mr. H. S. Russell (Messrs. Mirrlees, Bickerton & Day) said that Dr. Ferranti had expressed himself in favour of large generating stations driven by steam turbines, which was just what they could expect, because Dr. Ferranti was the pioneer of large generating stations and of extra high tension transmission. He could not agree, however, that the claims of the oil engine, and especially the Diesel oil engine, could be dismissed as lightly as Dr. Ferranti had done. He had argued that if electrical energy was required on a considerable scale over a fairly large area it must necessarily be the best thing to confine all the generating plant into one huge station and distribute it over the area. That of course meant extra high tension transmission, which was one of Dr. Ferranti's favourite things. It meant also a large number of sub-stations with motor generators or rotary transformers in them, so that it necessarily meant the employment of men in these sub-stations. His contention was that a far more economical scheme was to put down Diesel driven generators in the sub-stations and to dispense with extra high tension transmission and incidentally with the generating station. Dr. Ferranti had suggested that under his scheme of large generating stations the cost of labour would necessarily be lowest; but he thought it was fairly obvious that under the scheme he (the speaker) suggested it would not be necessary to have appreciably more labour, whilst on the other hand, the whole of the labour in the generating station and in attendance of the transmission lines would be saved. There would also be a big gain in efficiency because of the saving in losses in transmission and in transformation. It was usual in dealing with a big station to consider transmission and transformation losses as negligible, but he was sure that many who had such schemes would agree that they were a very considerable factor—Mr. Christie for one would agree. It was not much use trying to save 10 per cent. in generating costs if they were losing 15 or 20 per cent. in transmission and transformation. Dr. Ferranti said in his paper, "As we are a coal producing country, it is evident that coal is our natural fuel." That statement, however, contained an economic fallacy, because there were

obviously conditions which might arise which might make it advantageous for us to export our coal, and import some alternative fuel such as oil. He would give a parallel case. Ireland was a bacon producing country, and according to Dr. Ferranti, the whole of Ireland should be fed on Irish bacon, but the fact was that the whole of the Irish bacon was exported, the Irishman himself eating imported Canadian bacon. Even if it were admitted that coal was the best thing to use, it did not follow that steam raising was the best use for it, and he would like to remind the meeting of what Dr. Diesel said in his paper last year before the Institution of Mechanical Engineers. "As tar and tar oils are three to five times better utilised in the Diesel engine than coal in the steam engine, a much better and more economical utilisation of coal is obtained if instead of being burned in boilers and grates in a wasteful way, it is first transformed into coke and tar by distillation. The coke is used in metallurgical and other general heating purposes, from a part of the tar the valuable by-products are first extracted, and undergo further processes in the chemical industry, whilst the tar oils and combustible by-products and a great part of the tar itself are burned in the Diesel engine under extraordinary advantageous conditions." In the *Engineer*, in October last year, it was stated that by special processes for the production of tar oil from bituminous coal, it is contended that as much as 80 gallons per ton,or 40 per cent. of the coal could be converted into tar oil, and as the fuel consumption in the Diesel engine was probably less than one-quarter that of the steam engine at its best, it was obvious that even with coal as a fuel the Diesel engine had a great advantage. There were other advantages which everybody was well aware of, such as the absence of standby losses, and the fact that the engine was ready for starting up at a moment's notice, which was not the case with steam plant. There had recently been an attempt to show that under certain conditions of load it was possible to generate electricity with steam as cheaply as with Diesel engines, but the advocates of steam seemed to have overlooked two points. In the first place they reckoned their coal consumption in terms of the coal burned in the boilers, and not in terms of the coal bought. It was a well-known thing however, that where coal had to be stored for a considerable time, there was a great deal of wastage due to breakage and the blowing away of the dust, and it also deteriorated in quality. In large stations an enormous amount of coal would have to be stored for a very considerbale time, so that the actual amount of coal bought would very largely exceed that recorded as burned in the boilers. This might be anything

from 10 to 25 per cent. The second point was that when people were claiming a certain consumption of coal in steam plants, they reckoned with steam engines just as with Diesel engines, on the figures given by the makers' guarantees. It was well known, of course, that Diesel engine makers, when they gave figures for consumption, were always well within the mark; but the real point was that the figures which the Diesel engine makers were prepared to guarantee, and which they obtained on test, were also obtained in the actual working of the plant, and that was a thing which could not be said of steam engines. In 1909 a controversy was raging in Germany as to the relative economy of Diesel engines, and of superheated locomobile steam engines. An investigation was made of the stations using the two types, and it was found that in the steam engine stations the actual consumption which was obtained in the working was 102 per cent. in excess of the makers' guarantee figures, whereas with the Diesel engines it was only 14 per cent. in excess. There was only one other point he would like to touch on, and that was the question of supply and the price of fuel oil. Dr. Ferranti had said that "the very fact of oil being so sought after as fuel for certain purposes puts it out of the question for general power distribution," and he mentioned the consumption of light oil for automobiles and the use of fuel oil for the Navy. In fact, he made an appeal to the patriotism of the members to burn coal, because if they did not we might be invaded by a foreign power, owing to the Navy not having enough oil. In the first place, he would remind the meeting that where oils were distilled for the purpose of obtaining petrol and other light oils, it was the residual oils that were made use of as fuel in the Diesel engine, so that it was obvious that the greater demand there was for petrol, there would be available larger supplies of Diesel engine oil and not smaller. With regard to the use of fuel in the Navy, practically the whole of the fuel oil so used was burned in the boilers, but the present tendency was to increase the use of Diesel engines in the Navy, and as by burning the fuel in the engines instead of in the boilers, it would be possible to save 75 per cent. of it, it would seem that the more extended use of Diesel engines in the Navy would mean a reduction in the amount of fuel oil required, and not an increase. The present high price of fuel oil was interesting engineers very much, but he could assure them that it was not due to monopolies or any rigging of the market. It was entirely due to the want of transport facilities for bringing the oil over. He did not know if any of those present attended the Cantor Lectures, given by Dr. Vivian Lewes at the Royal Society of Arts in the early part of the year, but he stated

that while he could not hold out much hope of relief in price to the users of petrol, the position with regard to fuel oil was entirely different. He said there were huge stocks of fuel oil all over the world, and as soon as the tank steamers, which are now being built, came into service, there would be quite enough fuel oil, and it would go down to its normal price again. Incidentally, he mentioned that there was not an unlimited supply of oil in the world, but that there was no reason to trouble about a shortage for 100 years to come. His (the speaker's) firm was full with orders for Diesel engines for a long time to come, so that it was quite evident that the price of fuel oil had not frightened users. Owing to the long period of delivery which his firm was unfortunately forced to quote at the present time, those who were contemplating putting down Diesel engines could do so now, in the full knowledge that fuel oil would be cheap again before they could obtain delivery of their engines.

Mr. R. A. Chattock (Chief Electrical Engineer, Birmingham), said that the criticisms of Dr. Ferranti's paper which had been made were hardly justified by his own experience. Recently he had had an opportunity, in connection with a very large power scheme which was being got out in Birmingham for a new station, to go into the figures for steam and gas plant. He was in want of a very large plant in Birmingham to deal with his extensions and developments, and had in mind a station of the kind outlined by Dr. Ferranti in his paper, and was interested to see that these ideas fitted in with his own conclusions after having got out figures and considered them carefully. It therefore might be of interest to the Meeting to give briefly the results obtained in that comparison with steam and gas generating plant. Including the capital cost of the plant, the cost of labour for working, interest and sinking fund, fuel consumption, and all the items usually considered in works costs taken into account, he had ascertained that for a producer gas station working on a load factor of 27 per cent. which was about the average to be anticipated in Birmingham, the cost per unit was 12 per cent. higher with gas than with the steam plant; also in the case of a gas-driven station using town gas of high calorific value—about 500 B.Th.U. per cubic foot—and reckoning gas as 6d. per 1,000 cubic feet, the working costs were 41 per cent. higher than steam. He agreed that a 27 per cent. load factor was considered low for a gas-driven station, but he did not see how with any supply undertaking which had to deal with an average load factor of 20 per cent. to 25 per cent. one could hope to get

more than a load factor of 27 per cent. on a large portion of the generating plant, because plant of this kind would represent eventually something like 70 per cent. of the generating plant in the undertaking, and therefore it was impossible to treat it differently from the steam plant already there. The size of the units which he considered for the steam turbine plant was 5,000 k.w., and for the gas plant 4,000 k.w., which latter was the largest that had been commercially made up to the present. He also considered 1,000 k.w. gas engine sets and the figures worked out slightly higher than those for the 4,000 k.w. sets chiefly due to the extra cost of labour in running. This brought him to the point mentioned by Mr. Russell, in which he recommended the use of Diesel oil engines in sub-stations, and incidentally to do away with the generating station, but it seemed to him that for an undertaking requiring 100,000 k.w., which was quite a usual figure nowadays for the large towns, it would be necessary to have something like 200 Diesel oil engines running in these stations, and the labour cost of handling those engines appalled him. The question of coal deterioration in these large stations had been mentioned, and it had been said that from 20 to 25 per cent. more coal would have to be bought than was burned. Surely, however, the deterioration would still go on in the stocks of coal in a number of small undertakings, and if anything it would go on at a greater rate with small stocks than where it was kept in greater bulk. That criticism he really did not think was worth considering. Dr. Ferranti had drawn attention to the incapacity for dealing with overloads which oil-driven stations suffered from. This was a very important point when it was necessary to call upon the plant to deal with sudden emergencies due to breakdown or fogs or things of that sort, and if gas engines were called upon suddenly to deal with a heavy overload they would not stand up to it but would shut down. This was a very important point in considering the best method of driving generating plant, the reliability and continuity of supply were things which must always be kept in the front rank of requirements.

Mr. R. W. Weekes referred to the statement in Dr. Ferranti's paper that "A good steam turbine and boiler plant will to-day give back 15 per cent. of the energy of the fuel as electricity. As an high efficiency of 18½ per cent. has actually been obtained in practice." He, however, wished to talk about a steam plant which he had installed in various places in large units in which 83 per cent. of the heat that the engine took was turned into

electrical energy. If they took 85 per cent. of the total heat in steam as not being turned into useful work it would be found that the bulk of it went into the circulating water. For instance, at the works they were visiting that afternoon, at Deptford and West Ham, it would be found that the biggest part of this 80 per cent. was warming the Thames. Unfortunately, they were obliged to waste that heat in most instances, but there were a large number of works and factories, such as soap works, sugar refineries, etc., where steam heating was required. In these places low pressure boilers were installed in which the steam was often made at 60 lbs. and used at lower pressure. They burned coal in very much larger quantities than municipal electricity undertakings because it was quite usual to find 800 tons of coal being burned in a week, and he knew one case in which the figure was 2,000. If, in these works, high pressure boilers were installed working with high super heat, and the steam was passed through a turbine and then used for the heating process it produced power more cheaply than any other prime mover. In one works he was thinking of, this steam in going through the engine lost only 6 per cent. of its total heat. Thus if the steam was passed through an engine and turbine first, they would only require to burn 6 per cent. more coal than was burned now, and it followed that as all the boiler expenses and 94 per cent. of the fuel were really chargeable to the heating process, the cost of the unit would be very low. It might be said that everybody had not got soap works and sugar refineries at their doors, and that was so, but he wished to bring this point home to those present. In a particular works in 1900 he put in high pressure boilers and superheaters working up to 700 degrees. The engines were Easton engines and the steam consumption was 15·4 lbs. per k.w. hour. He went back to those works in 1908 or 1909, and extended the high pressure boilers, but instead of highly economical steam engines he used a simple steam engine with one expansion. The maximum load on that plant was only 400 k.w. The steam was taken into the engine at 200 lbs. and was turned out at 65 lbs. The steam consumption in the engine was 65 lbs. per k.w. hour, but the net result of the change was that in 1911 a saving of 4,000 tons of coal was made, and between the years 1909 and 1911 the cost of coal was reduced by £3,000. That was a 400 k.w. plant, and where many central station engineers with plants of similar capacity were burning 6 lbs. of coal per unit or even as low as 3, this engine was costing well under ½ lb. of coal per unit. This coal per unit was not increased if the engine wore, because if they drilled a hole in the piston and it let steam through, it would not raise the cost of

producing electricity. It would simply mean that more steam was passed into the sugar or the soap. If the load on the engine fell from full load to half load the cost of the coal did not go up, and where it was applicable it was a system which should be looked into. He knew of one works where up to 60,000,000 units could be generated by the system, but he regretted to say that although he had been working at it since 1906, he had not had any success with it when trying to sell cheap electricity to municipal engineers. In 1908 he introduced it to Mr. Seabrook, but he did not think much of it for West Ham, and in 1909 he introduced it to Liverpool, but the Liverpool people did not want cheap electricity. He believed, however, that the system could be used in many cases, and that it could produce, with a simple and cheap plant, electricity very much below price mentioned by Dr. Ferranti.

Mr. H. Gray (Chief Electrical Engineer, Accrington) said that the author of the paper and a considerable number of speakers seemed to have come to the fixed conclusion that the steam turbine was the prime mover of to-day and would continue to be so until the gas turbine arrived. Unfortunately practically all of them present had experience of steam turbines, but there were very few municipal undertakings which had had any experience of gas plants and by-product generation. There was only one public gas plant electrical generation scheme at present working, and that was in Accrington. It had now been running for eight months, and although with plants of this description it was not justifiable to give any statements as to costs for less than twelve months running, it might interest the meeting to have a few leading details as to what had been occurring during the last few months. The plant in question consisted of two 1,000 h.p. units with by-product ammonia recovery plant, tar recovery plant, exhaust boilers, etc. The object of the scheme was not to deal with all the units generated but avowedly only to deal with the 24-hour load units, i.e., the engines were put in to attain as near 100 per cent. load factor for the week as possible. Since they were started last winter one or other of the units had been running steadily day in and day out 164 hours per week as near full load as possible. The load factor as a matter of fact was 82 per cent. and it did not get any nearer to 100 per cent. owing to the unfortunate occurrence of Sunday with very little load. The load factor of 27 per cent. mentioned by Mr. Chattock was one which could not be considered for any gas plant with its higher capital value. It was necessary to have such plant running night and

day as steadily as possible. One of the units at Accrington was turning out an average of 86,000 units per week, and they had never been held up by it yet. As an indication of the fuel costs of the units generated for the last three months these were 1·56 lbs. or 0·125d. The by-product plant which had only been working a month or two was now working very satisfactorily and returned 0·078d. per unit, which was more than half the total of fuel costs. This was with the local Lancashire steam slack raised about one and a half miles from the works. If they thought it worth while to go further afield, say within the radius of 20 miles, the by-products could be increased considerably, but it was a pure question of whether it would pay to increase the cost for the fuel. Dr. Ferranti had compared the effieciency of turbine plant with gas plant, and he took it that this comparison was under full load conditions with no standby included. By including the standby in a gas plant the cost of keeping a 1,250 h.p. producer ready for work within a quarter of an hour for one week was slightly over half a ton of coal. This would compare very favourably with steam plant ; in fact it was negligible compared with keeping steam boilers under steam.

With regard to the overload of oil engines and gas engines if installed by themselves in generating works, they must of course hold their hand up to steam plant in this connection, but if the gas or oil engine was installed in connection with steam plant then the latter would handle the overload. It was equivalent to putting a steam cylinder on the gas engine. It was also possible to run a gas engine up to speed within 20 seconds and to synchronise within a minute and increase the output in that way.

Mr. E. E. Hoadley (Chief Electrical Engineer, Maidstone) said that unfortunately they could not be all engineers of large stations such as those advocated by Dr. Ferranti, or the large station over whose destinies Mr. Chattock so ably presided. Mr. Chattock had given a comparison between a gas-driven station and a steam-driven station for a large undertaking such as would suit the needs of Birmingham. He, personally, a short time ago had a similar problem on a somewhat baby line compared with Mr. Chattock's. He was putting in a now comparatively small unit of 750 k.ws. and he put it up to the makers of oil engines and steam plant to give their guarantee of consumption. He knew exactly from his previous practice what he could do in the matter of lbs. of steam per lb. of coal, and then worked out exactly the cost of generating 2½ million units per annum from this 750 k.w. set.

He took into consideration the cost of fuel, labour, in looking after the prime movers, lubrication, repairs and capital charges; and on the resultant figures it was decided to put in a steam generating set, there being no saving with oil. As a matter of fact, he concluded, he had gone into the matter rather prejudiced in favour of the oil engine.

Mr. C. H. Wordingham (Chief Electrical Engineer, Admiralty) said that Dr. Ferranti was consistent to the principles which he had advanced from his own boyhood and from the babyhood of the industry, and his paper dealt only with generation on a large scale. Most of them were familiar with Dante's "Inferno," and they were all now familiar with what he might call "Ferranti's Paradiso." All of those present might look forward to one or other in the future, but perhaps the Paradiso seemed the further off to many of them. He wanted to raise a very humble voice and to remind them that all of them in that room were living in the present, and that the future, when only large-scale generation would be in existence, was a good way off; they must remember therefore that small generators would continue to be used for some time, and to interest a good many people. Some few months ago he ventured to air his views on this subject, and suggested that much good might come to the electrical industry by generating electrical energy in those places where the demand was small, by means of gas engines. He was soundly belaboured, however, by both sides, and neither wanted to take advantage of the good things which he pointed out. Naturally, however, he was still of the same opinion, and thought that as a practical solution of the supply of electrical energy at the present time and for some time to come, a great deal might be done by means of gas engines of moderate size supplied with gas in conjunction with those who had made it the business of their lives to produce gas cheaply; therefore, while Dr. Ferranti's paper represented the views no doubt of all electrical engineers including himself at the present time who might have to design large generating stations, nevertheless those large generating stations were not the only ones to be catered for, and the small stations might well look into the merits of gas engines.

Mr. H. Richardson (Chief Electrical Engineer, Dundee) thought it might be interesting if he gave a few particulars of a similar comparison between steam turbines and oil engines to that made by Mr. Chattock, between steam turbines and gas engines. The units were the same size as in Mr. Chattock's case,

and although he had not gone into the percentages, the total figures were sufficient indication of where the advantage lay. For a 5,000 k.w. steam turbo alternator with boilers, coal bunkers, etc., the capital cost was, putting it rather on the heavy side, £30,000. With a Diesel engine he was willing to take the largest size that the makers could offer, and it was found that in order to do the same amount of work it would be necessary to have four Diesel engine sets, and the total cost, on the makers' estimates, not entirely including everything, and certainly not including any allowance for the greater space the machines would occupy, was £58,000. He could not speak as to the price of oil to-day It was a very unstable thing, but two years ago when coal was normal he had occasion to compare coal costs at his station with 2,500 k.w. sets with Diesel engines. At that time his intention was to make Diesel engines work as auxiliaries to sub-stations if possible. The result of his investigation was that the fuel cost for Diesel engines worked out to 0·15d. per unit generated, whilst the coal cost at that time was 0·11d. He believed the price of coal had gone up since, but in spite of the manner in which they had in the past slanged coal-masters, he thought they should give them their due as much as possible, and felt it would be wiser to depend on that market which was a much steadier market than the oil market had ever been in the past, and as to the future we had only interested prognostications. He quite realised, on the other hand, that the oil engine had its future both in marine and naval uses and also for the smaller stations which had to do with residential areas, but he could not possibly see that it had a future among those who had to deal with industrial areas. Mr. Russell had mentioned 15 to 20 per cent. transmission losses. Where were they ? Where did they come from ? He could not see them to-day. Perhaps in a very short run or during a fog such a loss might occur on the low tension distributors, but such a figure did not obtain under the conditions prevailing in a modern transmission system to-day. Two to 3 per cent. was more like it. One gentleman had mentioned Sunday as being an unfortunate occurrence. Sunday, however, was not an unfortunate occurrence, and those who ran internal combustion engines knew very well that it was a thing to be very thankful for indeed. Mr. Wordingham had mentioned that we were living in the present and that we should live in the present and not in the future, but his idea had always been that our principal faults from which we were suffering to-day were because in the past we had lived too much in the present, and he hoped they would look ahead, and he was in agreement with Dr. Ferranti as far as he had taken us in

the paper. It was not very far, it was true, but they knew there were good reasons for not going any further at the present time, and they could rely on Dr. Ferranti to bring about the solution that had got to come in the way of cheap generation. He quite agreed with them that they should encourage the manufacture of efficient machinery by buying machinery which generated cheaply, always provided that the capital was not too great; and this was the point he wished to bring out. In this country we had not got much water power. The term water power was a very effective catch-penny phrase. It caught the laymen in Great Britain. They heard of the wonders of Niagara and the wonders of the many waterfalls of the world and seemed to think that it was possible to get power for nothing. The fact was, however, that the civil engineering works in the utilisation of water power involved such a high annual cost in interest and sinking fund that it was simply hopeless to attempt to compete with it against steam in many cases. In Switzerland they were selling power to engineering works at 50 to 60 per cent. higher prices than it was now sold by several of the more progressive municipal electrical supply undertakings in this country. Water power was not an unmixed blessing, and if it was necessary to spend large capital to get cheap generation it did not necessarily follow that the final result would be satisfactory.

Mr. W. A. Chamen (South Wales Electrical Power Distribution Company), after expressing his entire agreement with Dr. Ferranti, said he had tried on several occasions to get some encouragement from oil and from gas, but they had always failed him. He was, at one time, minded to go in for huge gas generating stations, but for one reason or other he had not done so, and one great reason certainly was the difficulty of getting satisfactory generating sets in large units such as were necessary for the purpose. All that the makers could offer him were a lot of small sets, or what was the equivalent, some big sets built up with a lot of small cylinders, which was no good. When he was in trouble two or three years ago with the coal strike in South Wales, he thought he might get assistance from oil as fuel under his boilers if the coal supply was interrupted. There was a lot of oil available on the other side of the Bristol Channel, at the Avonmouth Docks, but he could not get it. The Great Western Railway Company would not take it through the Severn Tunnel, and he would have had to pay carriage on it right round by Gloucester. Therefore this idea fell through. He thought of getting it across by boat, but there again there was no

satisfactory means of doing it. In fact, oil had disappointed him most terribly. The price was not the least disappointing item, and it was impossible to put one's finger to a price which could be relied upon. There were, nevertheless, cases in which oil engines could be used with advantage, and Dr. Ferranti had hinted at them. He had had seriously in view the putting in of a 750 k.w., or a larger, oil engine at a standby generating station, in which the steam plant was not of a very economical type. Under the conditions, however, it seemed wrong to spend capital upon this standby plant, and therefore, in the end, he kept the station more or less under steam, coupling up the Lancashire boilers into a thermal heating system, all the blow-outs being connected together, and all the feed inlets, the boilers being filled up to the neck, and by firing one boiler it was possible to keep the whole lot hot, in order to deal with any emergency at short notice. That, although not entirely satisfactory from the purely engineering point of view, was the best practical solution he could arrive at in that instance. He could not at all agree with Mr. Russell's picture of sub-stations becoming small generating stations using oil. Mr. Russell seemed to imagine that sub-stations must have attendants, but that was not so at all. In most of the large transmission and distribution systems they were not bound to put in running plant in the sub-stations, and especially with A.C. plants attendants were not required except at a few central distributing points. Therefore, so far as he himself was concerned as a power company engineer, he endorsed entirely the views that had been put forward by Dr. Ferranti.

The President said that before calling upon Dr. Ferranti to reply he would like to say a word, particularly in reference to what had been said by Dr. Ferranti, that the Navy and marine service would take the whole of the oil fuel coming into the country. This was a criticism he had not been troubled with during the past few years, although he had had sufficient to worry him to a shadow up to the present time. The only hope he had at Kingston, where, like Mr. Hoadley at Maidstone, he was running quite a small station, was to run on water gas tar. In fact, he would be doing this soon, as already some very interesting runs had been made. But the only difficulty at the present time was to get hold of the tar, because it seemed to be almost a universal practice to ship the tar direct to Germany, where they dealt with it and recovered the various by-products. So that it seemed that in the future, unless something was done, we should be shipping water gas tar to Germany and then arranging to import water gas tar from there to England.

Dr. S. Z. de Ferranti, in reply, said that Mr. Wordingham and Mr. Richardson had both raised an interesting point of principle in relation to the present and the future, but the reason he thought that it was important to speak about the future was because an idea of what was likely to take place in the future would greatly help us in the commercial development of the present. He took it that most supply engineers were so busy struggling to produce a cheap unit, and to satisfy their clients that they did not always have the opportunity of thinking out what the developments of the future might be; and therefore it was, perhaps, a good thing that some people looked at the business from quite a different point of view, and occasionally reminded them how their present actions might be guided by what was going to take place in the future. On the other hand, the criticism might fairly be brought against him that he had dealt with this matter too much in the light of the present, because he had reminded them that they were practically all following one system of generating electricity, because they had no option of doing anything else. That was surely the present, and in touching on the future as he had done his view had been to emphasise the justification for the course they were now following; and apart from the question of fuel, the reason that they were not using medium size generating units of the internal combustion type, and using oil, was because these units did not exist to-day, i.e., they did not commercially exist. Something was known of what had been done with regard to producing medium size units of the internal combustion oil type for naval purposes. This had been quite enough to frighten the naval users, and he did not think that what had been done had got anywhere near what was necessary in connection with electricity supply. He had spoken in the paper on the question of what was the most suitable plant to use, but this question was very largely answered when they came to look into it by finding that, as a rule, there was only one type of plant which they could use to fill their conditions. He was most impressed with this when, some two years ago, he was at Gary, on Lake Chicago. At the great steel works there, where gas was a by-product, and there was an ample supply of good quality from the blast furnaces, they had installed some sixteen 2,000 k.w. gas engine-driven alternators. The engine house was an immense one, the installation was fairly big, 32,000 k.w. altogether, and it was working under conditions which gave it every chance. There was a practical demonstration of the thing on a fair scale. Why was it that the Commonwealth Edison Company of Chicago, one of the biggest makers of electricity

in the world, and who made about as much as all London put together, did not instal a similar plant and put up producers to work it by ? All that he could say was that the Commonwealth Company were money makers, their living depended upon supplying the public at a sufficiently low rate, and they found that it did not pay them to do this. Their latest station, the North-West Power Station, was started up with 20,000 k.w. turbine units. Since then they had ordered from Sir Charles Parsons a 25,000 k.w. unit, and they had just contracted for a 30,000 k.w. machine from the General Electric Company. So that with all this gas engine experience at their doors, and also with 4,000 h.p. gas engines working most perfectly at South Chicago this Company had found that it did not pay them to put in gas engines in preference to these big turbine sets. The answer to most of the criticisms as regards what was right and what was wrong, and what they should do and should not do was that there was in each particular case just the one thing that could be done, and despite anything that might be said, this would continue to be the answer, and everybody would go on doing just what it paid them to do. Otherwise they would have to get out and let someone else do it for them. He did not wish to disagree at all with people who installed Diesel engines for certain purposes. These certain purposes, however, were nearly always small supply, and he maintained that the whole tendency all over the country was towards the business being done on a bigger scale. The very change from a purely lighting supply to one which included the business of heating and cooking was evidence of this. Having spoken these generalities, he would like to deal in detail with one or two of the points raised on the paper. It was a most fortunate thing that Mr. Gray, of Accrington, had put down gas engine plant, which he was quite sure it would pay his Corporation to use, and it was going to be of immense service to the community in getting experience in a most important direction. This experience would help to supply a link in the chain which went to form the future work of generation when all the coal would be turned into gas, and the gas used in some form or other, whether under boilers or not he would not say, and then used to produce electricity. Mr. Weekes, in not wishing to take up too much time, had only given a partial explanation of the system he was interested in. If steam was generated in a boiler, and passed through an engine, and then the remaining heat units in the steam were used for purely heating purposes, the h.p. was obtained very cheaply if the steam was credited with the whole of the heat units that it turned on to the remaining process ; but if this

country were to follow any such plant generally, apart from special cases, it would be overflowing with sugar and washed away with soap. Of course, less coal per unit produced was used, but that was not the whole question. Far less would be used, if the circumstances permitted of water power being available. So that he was afraid that although he did not wish for one moment to detract from the desirability of individual factories utilising their plant so as to keep their generators working economically in the way Mr. Weekes had suggested, it was not a thing which applied to the supply business generally. With regard to Mr. Chattock's remarks he had no criticisms to make. Mr. Chattock had told them what he knew, because he had had to solve a definite business problem, and he was satisfied that it had been solved in the most efficient way that was at present available. Mr. Russell ably represented Messrs. Mirrlees, Bickerton & Day, the makers of Diesel oil engines. Mr. Day was an old friend of his, and he had had the opportunity of seeing the splendid works which had been erected by him for the manufacture of Diesel engines, where they were produced in as perfect a manner, from the scientific and business point of view, as one could imagine, and he was delighted to know —what he knew before Mr. Russell spoke—that notwithstanding the high cost of oil, the firm had business which would occupy them to the fullest extent for at least two years. It only showed that it was fortunate that municipal electrical engineers did not depend on Diesel engines for generating electricity, because under the circumstances the supply would run very short. As to Mr. Hoadley's remarks, when he commenced to speak, he (Dr. Ferranti) had made the note that he would not pretend to recommend steam for comparatively small sizes; but Mr. Hoadley had told them that as the result of an actual trial, by getting the prices and considering costs he had found that it paid to instal steam in preference to something else—so that this was rather an argument outside what he personally was going to use. Dealing with the question generally, he thought it would be a very desirable thing if municipalities and companies could work together and avoid the installation of these small generating units and small generating stations; and in spite of the fact that he entirely disagreed with municipal trading, it would also be a good thing to the same end if municipalities could supply outside the areas at present allotted to them. If this could be done it would remove one of the arguments against municipal trading, and incidentally muncipalities should have powers to do everything necessary to encourage the use of electricity. He would only say that, as

municipal trading was in existence, let municipal electrical engineers do it well. This was very closely allied to the question of prime movers, because it would enable larger areas to be supplied from a centre or from several centres, and would bring us nearer to what he considered to be the ideal necessary in the way of cheaper generation. It was felt that the larger municipalities could beneficially supply the smaller communities on their boundaries, and he was quite sure that if the difficulties, whatever they might be, could be got over, it would be a very beneficial thing for the community at large.

A hearty vote of thanks was accorded to Dr. Ferranti at the conclusion of the discussion.

Incorporated Municipal Electrical Association.

THURSDAY, JUNE 19th.

MEETING AT KINGSTON-UPON-THAMES.

The Association met in the Empire Theatre, Kingston-upon-Thames, and was welcomed by His Worship the Mayor (Councillor C. H. Burge, F.I.C., Surrey County Council).

The Mayor, in giving the Association a hearty welcome, said that in Kingston they rather prided themselves on the fact that, although it was a small borough, it was a very ancient and a Royal one. It was fortunately situated in a most charming locality and he hoped that their visit in the afternoon to some of the beauties of the place would be most pleasurable. Dealing with the programme for the morning, he alluded to the paper on " Electric Vehicles," and looked forward to the time when all vehicles could be economically driven electrically, a result which would do away with the unsanitary conditions incidental to the older method of traction. Electrically-driven vehicles also would be preferable to petrol vehicles which occasionally did not have the perfume of otto of roses about them. The other paper on the Filtration of Air also suggested possibilities of a general character in regard to the atmosphere of large towns, and anything that could be done towards the purification of the atmosphere generally was to be welcomed.

The President, in proposing a hearty vote of thanks to the Mayor for his kind welcome, said that as an Association with only eighteen years to its credit, he hardly cared to talk of age in a town where thirteen years ago people were celebrating the thousandth anniversary of the crowning of Edward the Elder. Although they were young as an Association they had, he thought, done a good work in the past, and hoped to do good work in the future. The fact that the Association consisted of representatives of municipalities who controlled roughly £1,200,000 capital, spoke fairly well for itself, and he hoped with the kind assistance of their Councils, Borough Treasurers and the Local Government Board, to see that capital very largely increased and multiplied, because an increase in capital expended upon electrical undertakings meant that they were doing something good for the community generally. He was one of those who thought with Dr. Ferranti that it was merely a question of a few years before practically everything, such as heating, lighting and cooking, etc., would be done by means of electricity in some form or another, and that the saying that " electricity is a poor man's light " would not be treated with a certain amount of derision, as it was now, but would be an accomplished fact. Whereas now people spoke with a certain amount of surprise that certain things could be done by electricity, the fact that everything could be done by electricity would in a very short time be a matter of such common occurrence, that they would think no more of it than eating their breakfast, and he believed that this would be brought about eventually as Dr. Ferranti had said, by schemes involving the transformation of coal into electrical energy at the coalfields, possibly gasifying our coal at the coalfields and using internal combustion engines of such units as at present we dared hardly think of, and the transmission of that energy to all parts of the country. When that time came we could get rid of all smoke nuisance, and fogs would be a thing of the past. In fact all useful work would be done by electrical means. In conclusion, he expressed his gratification at such a large attendance in Kingston that morning, as it indicated a very hearty and unanimous support of himself as President of the Association.

Mr. C. H. Wordingham, in seconding the vote of thanks to the Mayor, said that he spoke as a Past-President, one who belonged to the last century. It was many years ago, in the very early days of the Association, that he had the honour of presiding over a very much smaller gathering than the one forming the Convention this year. He was one of those who felt, in the early days, how valuable it would be to the Association if they could get the co-operation of the chairmen and members of the electric lighting committees, and there was no doubt now, that that opinion had been abundantly justified. The Association owed much of its strength to the fact that it combined as its members, engineers and members of committees, for not only was the wisdom of the Association added to thereby, but the splendid way in which the municipalities of the country had from year to year entertained the Association had done much to promote the success which it had attained.

The Mayor expressed his gratitude to the meeting for the cordial way in which the vote of thanks had been received.

Air Filtration, Cooling and Ventilation of Electrical Machinery.

By J. CHRISTIE,

Engineer and Manager, Corporation Electricity Department, Brighton.

THE following notes are intended to apply to the air filtration, cooling and ventilation of large steam turbo-driven alternators, such as it is common practice to instal in modern power-houses.

As constructed by leading manufacturers, these sets are now supplied under the most stringent guarantees as regards steam consumption, coupled with reliability and liberal overload ratings; in fact, within limits, the only condition governing the outputs obtainable from them is the temperature rise which the electrical windings and their insulation can safely withstand.

Till a few years ago such machines were run with open ends and natural ventilation, but the temperature rise, even on less than full load, was often excessive. By fitting end bells, air ducts and forced ventilation, the makers without any very material alteration in the design have with the same carcase been able to double the output with a decreased temperature rise, whilst the selling price per kilowatt of

rating has been proportionately reduced. All this has proved a great boon to the purchaser, but the advantages thus gained have brought in their train a host of minor though still serious difficulties in the way of filtration and conditioning of the air which, so far, have only been dealt with in a rather crude fashion by means of cloth screens.

To effectively cool large units of plant with the surrounding air at normal temperature, some 5 to $7\frac{1}{2}$ cubic feet of air per minute per kilowatt of rated output must be forced through the windings of the machine, the general practice being to draw this from outside the building, or, where the conditions are favourable, from the engine room basement, the circulation being effected either by separate motor-driven fans or by fans fitted to the rotating part of the machine itself.

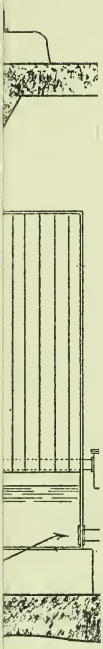
For moderate sized units of, say, 3,000 to 5,000 kilowatts capacity at speeds of 1,500 revolutions per minute, I favour this latter arrangement, as being cheaper, more efficient and reliable, but for large slower speed plants and where there are several of these sets working together, then undoubtedly the best lay-out is to provide main inlet and outlet ducts common to all machines with branches and dampers to each unit, and to have a combination of fans on the rotors themselves supplemented by separate motor-driven fans for heavy overloads, the air filters being fitted at the ends of the intake duct and preferably in a suitable chamber outside the building.

All air about a power-house, no matter how cleanly the surroundings may be, is heavily charged with dust and fine gritty particles in suspension, and unless every care is taken to filter it before passing through the machine, the windings become coated and the air ducts choked up, and with the consequent rise in temperature the efficiency of the machine rapidly falls off. A sensitive air gauge is a most useful accessory to fix on the main air duct to the machine, as it shows the attendant at a glance the actual condition of the ventilating system.

Where no filters are provided, there is little doubt but that the condition of the varnish and insulating fabric on the end windings becomes in time seriously affected by the heat and the constant sandblast action which takes place due to the large volume of grit charged air moving at high velocity over their surface, thus making it porous. If a machine in this condition is allowed to cool down in a humid atmosphere, the insulation, due to the absorption of moisture, rapidly falls below a safe figure, and this I believe is the real cause of many mysterious " burn-outs " for which it has been difficult to account. Most of you who have had this unpleasant experience will, I think, agree with me that such failures have generally occurred when a machine has just been run up and put on load after a lengthy rest.

The type of air filter most commonly in use consists of closely woven cloth, tightly stretched on suitable wooden or wickerwork frames, and so arranged as to present a large area to the incoming air, thus keeping the velocity and pressure on the fabric at this point as low as possible. The general practice is to allow one-fifth of a square foot of filter medium per cubic foot of air per minute. This is approximately equivalent to one square foot of area per kilowatt of rated output, and in the case of large machines it becomes a most unwieldy surface to handle efficiently. At best, this type of filter can only be regarded as an unsatisfactory makeshift and it possesses the following disadvantages :

(1) The large space occupied in proportion to its capacity.
(2) It requires cleaning at frequent intervals.
(3) The filter cloths wear out quickly and are expensive to renew. (£75 to £100 per annum for cloth and labour is by no means an outside figure for the efficient maintenance of such a filter on say, a 3,000 kilowatt set of plant.)
(4) The cleaning of the filter is a long and dirty job, and can hardly be accomplished without taking the machine out of service for some considerable time.
(5) Owing to its combustible nature it is a hazardous fire risk.
(6) Unless of liberal area it quickly chokes up, and the air pressure rises till the fabric bursts. It is well to note that the air pressure on the intake duct of a machine should not be allowed to exceed one to one and a quarter inches of water, otherwise there is a grave risk of oil vapour being drawn in from the bearings if the oil is run at the excessively high temperature one usually sees on turbine installations, and this has a most harmful effect on the insulation.



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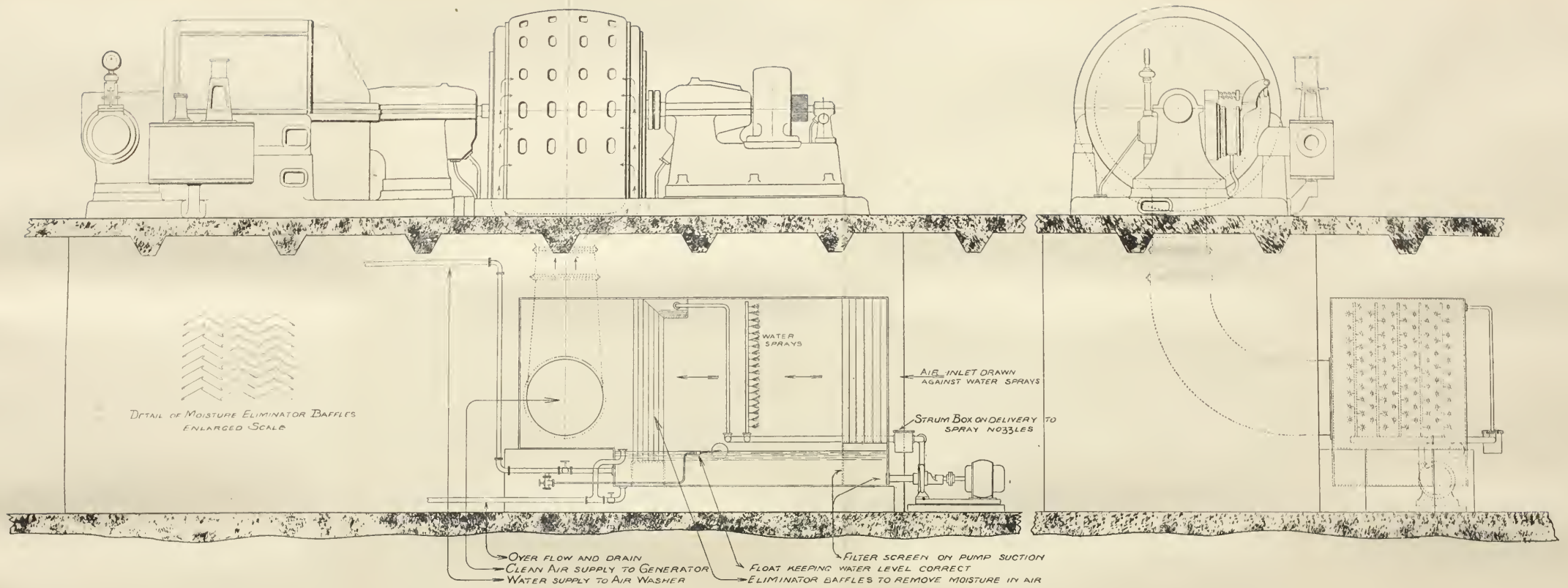

WATER SPRAYS
AIR INLET DRAWN AGAINST WATER SPRAYS
STRUM BOX ON DELIVERY TO SPRAY NOZZLES
DETAIL OF MOISTURE ELIMINATOR BAFFLES ENLARGED SCALE
OVER FLOW AND DRAIN
CLEAN AIR SUPPLY TO GENERATOR
WATER SUPPLY TO AIR WASHER
FLOAT KEEPING WATER LEVEL CORRECT
ELIMINATOR BAFFLES TO REMOVE MOISTURE IN AIR
FILTER SCREEN ON PUMP SUCTION

GENERAL ARRANGEMENT OF AIR WASHING & CONDITIONING PLANT No 5 TURBO ALTERNATOR

BRIGHTON CORPORATION POWER HOUSE SOUTHWICK

SCALE 1/2 INCH TO ONE FOOT

As an efficient substitute for a cloth filter, a suggestion was put to me last year to use a water spray screen such as is fitted in the " air conditioning chamber " in the Plenum system of ventilating large buildings, and facilities were afforded me for inspecting such an equipment in connection with a large institution in London.

On the face of it, at first sight, it strikes one as a rather daring proposition to pass air through water then directly into the internal anatomy of a high-tension alternator, but I was so satisfied with the experiments which I was kindly enabled to carry out that I had no hesitation in recommending my Council to purchase a suitable apparatus of this type for the last new alternator installed at our Southwick Power-House. It consists (*see* drawing) of a strong rectangular galvanised sheet iron chamber, one end (the air intake) being open and fitted with louvres. This opening is of such sectional area that the velocity of air at this point when the machine is going full blast is comparatively low.

In our case this filter is fixed in the basement adjacent to the machine foundations. Some 2 feet inside the air inlet a water screen is fitted. This consists of a series of small nozzles pitched 6 inches apart uniformly over the entire area. Some 6 feet beyond the screen a moisture eliminator is fixed. (This is a sort of baffle, very similar to that used in an oil separator such as is fitted in the exhaust steam pipe between the low-pressure cylinder of a reciprocating engine and the condenser.) Thence the air passes directly into the alternator.

The base of the chamber forms a fresh water tank holding some 300 gallons, and is fitted with a ball cock off the town mains to keep the level constant and to make up for any evaporation.

A small motor-driven centrifugal pump about 2 h.p. circulates this water at a pressure of 20 to 25 lbs. per square inch through the system. The nozzles project this water in the form of a finely atomised spray directly against the

incoming air (this space, when the apparatus is working, having the appearance of a dense steamy bank of cloud), and all solid matter in suspension in the air is caught and precipitated in the tank. Any beads of moisture or grit carried through with the air are effectively trapped by the eliminator, and nothing but pure cool humid air is carried into the machine. In some localities during the winter months with this class of filter it will be desirable to fit a small steam coil in the water tank just sufficient to keep the water from freezing.

The advantages claimed for the water screen filter are :

(1) For equal capacity the space occupied is less, and in the case of large machines only about half that of a cloth filter.
(2) No fire risk.
(3) The apparatus is quickly and easily cleaned, it being only necessary to drain off the water at intervals depending on the amount of dirt in the air (once every two weeks in our case is often enough), wash out the tank with a hose pipe, fill up and start the pump again. All this can be done in a few minutes and without even taking the machine off load.
(4) No costly filter cloths to frequently wash and renew.
(5) The resistance to the air is always constant, and is less than one-third that of a cloth filter, so that the power for driving the main fan is proportionately less, whilst the total energy consumed by the outfit as a whole shows a substantial saving over that required by a cloth filter, after making full allowance for driving the water circulating pump.
(6) The air after passing through the filter is not only pure, but is generally several degrees colder than the surrounding air, due to its being reduced to wet bulb temperature, consequently its cooling effect on the machine, volume for volume of air, is proportionately greater, this difference in temperature being generally most marked in the summer time just when the extra cooling effect is of the greatest value.
In tropical climates or in situations where the surrounding air is at an abnormally high temperature, it is possible, by introducing a small refrigerating plant into the water circulating system, to 'super-cool' and control the temperature of the air down to a degree far below the corresponding wet bulb temperature. Experiments which I have carried out show that it is possible by this means to reduce the temperature of the air to within a few degrees of the temperature of the water through which it is passed."

The first cost of a water screen filter, of course, varies with the size of the alternator to which it is fixed. In machines of, say, up to 3,000 kilowatts it is some 60 per

cent. greater than a cloth filter, but in the case of larger machines of 5,000 kilowatts and upwards the advantage as regards price lies with the water screen type.

In my opinion, due to the increased cooling effect obtained, especially during hot weather, an extra 10 to 15 per cent. overload can be carried on any machine so equipped without increasing the temperature rise, and if a super-cooling refrigerator is fitted in the water system, this overload capacity can be still further increased to 25 or 30 per cent.; in fact, I firmly believe that in the near future turbines of ample power to carry extra heavy overloads will always be provided. The attendant will then simply load up the alternators to which they are coupled till their temperature attains a predetermined maximum safe limit, and electrically-controlled thermometers on the switchboard for this purpose will supersede the ampere and watt meters now used. This extra cooling effect is perhaps the chief advantage of this system, especially where large units of plant are concerned, as the additional outputs obtainable for practically the same capital outlay amply justifies its general adoption.

The conditions of service under which the Southwick machine operates is generating three-phase alternating current, 50 periods, at 8,000 volts with 250 volts excitation on the field windings. Our equipment was, I believe, the first to be installed in this country and has been running since August last with entire satisfaction, and the insulation resistance has been consistently maintained, showing that any moisture carried through with the air is harmlessly evaporated on the warm windings of the machine, and that this type of filter may with safety be used for ventilating extra high-tension machines or air cooled transformers without detriment in any way to their insulation. The additional humidity in the air really has a beneficial effect on the insulation, preventing it from being baked to destruction as is not uncommon where machines are run at high temperature and heavy overloads with dry, hot, gritty air constantly circulating through their ventilating ducts.

Several engineers who have extensive installations of cooling towers in close proximity to their ordinary cloth air filter intakes have kindly furnished me with the percentage of humidity in the air as now used. This is often found to be as high as 90 to 100 per cent., so that they are really working almost under the same conditions with their present filters as regards risk, if any, to the insulation due to humidity, but without the cooling and cleansing advantages of the water screen.

With the gigantic units of plant, 10,000 kilowatts and upwards, now being installed by many of the principal undertakings throughout the country, this system of water screen filter seems to offer, so far as present knowledge goes, the most satisfactory solution of this somewhat difficult problem of suitably conditioning the air to be used for their effective ventilation.

DISCUSSION.

Mr. J. Christie, before the discussion was formally opened said he would esteem it a great favour if any of the manufacturers who took part in the discussion could give their views on the minimum insulation resistance which they considered safe for alternators of 10,000 volts. This was a point that he had discussed a great deal with several manufacturers, and he was very sure that any views they might express, would be very interesting.

Mr. K. O. Hale said he had been a strong advocate for a long time of the principle of the water spray system of filtering. It went without saying that it was some time before he did much good on the question, and could convince electrical engineers that there was something in the system. The time arrived, however, when he got Dr. Ferranti to place the first order, and since then Mr. Christie had had quite a long experience. He was more than convinced now with an experience of air filtering extending over four or five years, that there was no doubt whatever that this system must take the place of all cloth filters for obvious reasons. He would be very interested to hear what the generator builders had to say especially on the question of high voltage machines. Looking at it from the filter point of view, he could not see how the conditions were different from those which they had been used to in the past. The makers of the system guaranteed to put air into the generator entirely free from entrained moisture, and nature had not given that guarantee in the past. The air at present put in was very much charged with moisture, and was also humid, but with this system they not only got the advantage of a better system, but the greater advantage of cooling the generator. He had felt some very warm generators in his time, and obviously there must be some benefit in reducing that final temperature.

Mr. D. Bennett (Messrs. Balcke & Co.) said that Mr. Christie had brought before the Convention a subject which at present was receiving much attention from all power station engineers and others who were using turbo-generators, in a paper the title of which was very comprehensive, but which really made a rather one-sided comparison between the two types of filters usually in use. Most of the debatable points appeared in the numbered clauses on pages 40 and 42, and he would like to refer to these more or less in detail. Taking the wet filter first. It had certain advantages over the cloth type of filter, but they were by no

means so overwhelming as might appear from the statements made in the paper. Referring to the claims made for the water screen filter it was true that there were no cloths to clean and renew, but the parts in a wet filter which would wear out first, would probably be the separating baffles at the air outlet end. These were subject to a current of air which would have a certain amount of moisture in it, and there was undoubted risk of serious pitting occurring after the plant had been in use for a short time. This might be guarded against by special painting at regular intervals. He would like to know whether any signs of corrosion had been noticed in the filter at Brighton. With regard to the claims that the resistance to the air was less than one-third that of a cloth filter, no definite figures were given. Would Mr. Christie state what the exact pressure resistance was in his case? The extra overload which it was claimed could be obtained when a wet filter was used, appeared on the high side, but no doubt such increased loads could be obtained if a refrigerating plant was used to cool the air down to a sufficiently low temperature. The use of such plant might be the next development, but it certainly introduced considerable complications, and must also have an appreciable effect on the first cost and the running cost of the plant. With regard to the dry air filter and the disadvantages set out in the paper. Wet filters for large duties—say 5,000 k.w. and upwards—would occupy less ground space than dry filters designed for an initial pressure resistance of 1 mm. water gauge, but the dimensions would be very slightly less than those of filters designed for an initial pressure resistance of 3 mm. water gauge. In industrial cities, such as Leeds or Manchester, it had been found necessary to clean dry filters only six or eight times a year, whilst wet filters in similar situations would require to be cleaned once or twice a week; even in such a favourable situation as Brighton, it had been found necessary to clean the filter once a fortnight. With reasonable care cloth filter pockets would last quite two years. The estimate of £75 to £100 for cloth and labour required to maintain such a filter was much too high. A filter for a 3,000 k.w. turbo-generator designed for an initial pressure resistance of 1 mm. water gauge would have 60 pockets divided into four sections of 15, or two sections of 30 pockets. With the most modern type of construction the whole of the pockets could be changed and cleaned by two men in about 12 hours at a labour cost of say £8 per annum. The work could be done in a much shorter time if a complete set of spare pockets was available. The cost of this would be £33, and as they would last two years, the annual cost would be say £16 10s. If we

added this figure to the previous figure mentioned for labour, we get a total of £24 10s. as representing the outside cost of maintaining a 3,000 k.w. filter in good condition. It had just been pointed out that a well designed filter could be cleaned in a comparatively short space of time. It was advisable to shut the machine down for cleaning, but the time during which the machine was out of commission need be very short indeed, even if only one spare section of pockets was available. In such a case the plant would be shut down, one section of pockets removed, and the spare set placed in position. The dirty cloth could then be cleaned at leisure and changed with another set at the next opportunity. The most convenient method of cleaning the pockets was by a vacuum cleaner. connected to a condenser or air pump. The fire risk was very little greater than with a wet type filter. The timber and cloth could be impregnated to render same flameproof ; such impregnated material would not of itself burn or spread flame. If fire was maintained in close proximity to the material, the latter would char, and in time break up, but the effect would be quite local. Mr. Christie must have had an exceedingly cheap filter if the cloth burst whilst in use, or else the plant must have been kept in service until pressure resistance reached a very high figure. The area of cloths as suggested by Mr. Christie was sufficient to ensure that the initial pressure resistance did not exceed about 1 mm. water gauge. In a recent instance a filter was started up with a pressure resistance of 1 mm., and after running for six weeks night and day without stopping at all, the resistance rose to only 5 mm. when the first section of pockets was changed. This could not by any means be considered a high pressure in view of Mr. Christie's statement that the maximum pressure should not exceed 1·25 inches. In view of this statement, it would be interesting to know what pressure resistance had to be overcome by the air passing through the filter at Brighton. He had a small model filter which had been designed to overcome the objections and disadvantages found to exist in earlier designs. He felt sure that this filter in no way merited the description " crude " which was applied by Mr. Christie to cloth filters in general. The filter was built in sections having any number up to 30 single pockets per section. There was nothing unwieldy about it—one pocket and frame weighing about 14 lbs. One complete section was controlled, adjusted or released by operating only four bolts which were accessible from the outside of the filter casing. Was there not serious risk in the wet filter of excessive moisture reaching the generator by way of the filter when plant was shut down, and

which would settle on windings and possibly cause a breakdown when the generator was next started up ?

Mr. R. J. Kaula (Messrs. Willans & Robinson, Ltd.) said Mr. Christie was to be congratulated on taking the rather bold step of adopting a wet air filter, and possibly generator makers had some doubts as to the advisability of doing this. The point to be watched in the use of these air filters appeared to be the temperature of the air.

So long as the temperature of the air leaving the generator is well in excess of the temperature at the point of entrance, the air would be capable of absorbing a reasonable amount of water which might be held in suspension and carried past the moisture eliminators, but if the generator was running on light load and the rise in temperature of the air was very small, then there might be some danger through depositing of such water, and he would suggest that it might be advisable to turn off the sprays before shutting down the plant, so as to pass the dry air through the generator thus absorbing any moisture which had been deposited.

Whilst air filters were very useful preventatives of breakdowns, the fact could not be overlooked that breakdowns occurred even where all possible precautions were taken.

With the forced ventilation now universally adopted on turbo-alternators, the danger had to be faced that a comparatively small arc or short circuit within the machine is apt to burn out the complete windings.

He therefore considered that it was of the utmost importance to provide dampers which could be quickly operated both on the inlet and outlet of the air so as to shut off the air current immediately a breakdown occurred, as otherwise there was the danger of converting the generator into a blast furnace before there was time to shut down the turbine.

Mr. S. E. Fedden (Chief Electrical Engineer, Sheffield) said that before making one or two remarks on the paper, he would like to remind the members of what occurred in that building a few years ago. At that time they were in the early stages of the turbo-alternator, and he was one of the first to go in for turbos on a big scale. At that time he made the statement that his oil was 0·004, whilst the ordinary oil was 0·2, or something like that. There was such a sigh at such a huge lie being told that a candle

on the table fell to the ground. The paper to-day, however, proved that what he said then was absolutely right, although nobody believed it at the time. There was a remark in the paper with regard to fans on the rotors or independent fans. Very little was known about the ventilation of alternators, either by fans or by independent fans. He had a case of a 8,500 k.w. alternator with its own fan, which had to take a load up to 12,000 k.w., when used with an external fan. Without the latter fans it drew a suction of $\frac{3}{4}$ inch, and when the machine was shut down and the motor-driven fan was pumping air into it, there was an air pressure of 2 inches. Further, when the machine was running with the external fan in use the *suction* of $\frac{3}{4}$ of an inch was converted into a *pressure* of $\frac{3}{4}$ of an inch; so that it seemed to him that there was something to be learned from these figures, and the external fan appeared to have to get over or annul the suction in some way before any useful work could be got out of it. He had the same effect with the balanced draught. On the boilers the makers put a forced draught in, as well as an induced draught, in order to get a balanced draught, and they had to absolutely double the size of the motor on the induced draught before they could get any good effect at all, and it was a point worth considering. Mr. Christie said that there must never be more than $1\frac{1}{4}$ inch pressure, but surely the greater pressure in the alternator, the better the cooling effect. Mr. Christie also said that if a machine was shut down for any length of time and started up again, there was the liability to a burn-out. He thought they all knew that was the case, whether they had the dry filter or the wet filter. He would like to ask manufacturers why they refused absolutely to guarantee their machines if this wet filter was put on? At what voltage did they allow this filter to be put on, and why? He hoped they would hear from manufacturers as to the reasons why they objected, because it seemed to him that the air from this filter, if it was properly regulated, was very little wetter than the air on an ordinary wet foggy day, and the advantages to be derived from it were very great.

Mr. A. Hugh Seabrook (Chief Electrical Engineer, Marylebone), said that when he first heard of these filters from Mr. Christie, to whom, by the way, they were very much indebted for bringing the question before the Association, he asked the contractors for the two 3,000 k.w. 6,000 v. alternators of the Oerlikon type, which had been ordered by his Committee, to instal wet filters, but they would not hear of it, and said that as they had quoted for dry filters he would have to have them. He asked them,

however, to go into the question closely with their designers in Zurich, which they did, and he afterwards took their London man down to Brighton to see the machine running. When they got into the train at Victoria their representative said that there really was no need to go down because he was quite converted, and had, in fact, ordered eight wet filters and cancelled the order for eight filters of the other type. On the Continent this question of wet filters did not seem to be known at all, and once again the Municipal Electrical Association had been in the forefront.

Mr. F. H. Clough (B.T.H. Co.), said that he had not had much experience with wet filters, and it was difficult to express a very definite opinion, but he had seen Mr. Christie's installation, and certainly it was very convincing. It was working very satisfactorily, and, as far as could be seen, there was no free moisture entering the generator at all, and as several speakers had said, there was no reason why such a system should not be as satisfactory as the air going in on a foggy day. Recently manufacturers had been striving to prevent dynamos catching fire, when a short circuit occurred, and for that purpose they had introduced mica and asbestos very largely into the insulation. These materials, however, were not so water resisting as some of the varnishes used previously, and it would be necessary when wet filters were introduced to see that an ample amount of varnish was put on all parts, especially just on the outside, and if this were done, there should be no doubt that this type of filter would work quite satisfactorily. He certainly thought that they had a great many advantages over cloth filters, and it would be interesting to hear what users of these new filters had to say with regard to their experiences. The question was asked as to what insulation resistance should be allowed. A rough working rule, perhaps, was to divide the voltage at the terminals by the k.w. capacity of the plant, plus 1,000. The insulation resistance was $\frac{\text{Volts.}}{\text{Kw.} + 1000.}$ not an entire guide, but he did not think it should drop below the figure given by that formula.

Mr. O. Feldmann (A.E.G. Co.), thought it was not quite fair to call the cloth filter, which had served its purpose very well up to now, a crude method of cleaning air and an unsatisfactory makeshift. He could fully endorse the statements made by Mr. Bennet on the subject. There had certainly been very little experience with washing air by means of the spray filter in connection with generators, and he thought manufacturers could be excused for hesitating to adopt the new system hurriedly. Cloth filters were very simple and very easy to clean. Manufacturers

could not be asked to accept these sprays filters straight away on account of the insulation of the windings, for which the process of passing air through water and then drawing a humid atmosphere into the generator seemed dangerous, especially when starting up. It was impossible to clean air whilst starting up, whereas as regards the cloth filter, it was possible to clean it whenever the generator was running. It was not necessary to stop the machine for cleaning an air filter, as seemed to be indicated in the paper, and the generator could be started up whilst it was in commission. He could quite understand the utility of the spray filter in cases like Deptford, where it was necessary to clean the air in a limited space, and where they had a warm generator, *i.e.*, where the generator and the turbine were not equal as to their full load capacity. It was preferable to have the turbine to give its maximum efficiency at the full load of the generator, but in cases where this was not done, it might be a great advantage to increase the capacity of the generator by cooling the air by means of the spray. Of course it was also possible to adopt the same method by introducing a refrigerating plant for cooling the air and using a cloth filter. It seemed to him rather complicated to have a number of pipes and a tank which might be subject to corrosion through the water and would require painting or regalvanising in the course of time. There was also a motor and starter to be looked after, and the man who attended to the turbine had to go down several times during the day to see to the motor and starter, whereas, with the cloth filter, he need not trouble at all. The experience of the firm which he represented, showed that it was not advisable or profitable to have two fans in series as was suggested in the paper. The idea seemed to be to increase the volume of air through the machines when the set was running at overload by passing the air from one of the fans on to the other fan on the rotor. In his firm's experience this had not been worth while. A very interesting remark was made in the paper as to the future switchboard with thermometers probably calibrated in amperes. He could not quite follow this. It seemed to him that there would be a considerable time lag between the indications of the thermometer and the load on the generator when starting up, as the temperature of the machine would not rise very rapidly. It would take six or seven hours before the temperature was permanent at full load, so that in the first few hours the thermometer would not show the exact conditions. The same thing applied in the case of slowing down and taking the load off, the thermometer would not follow the fluctuations in load.

Mr. J. Shepherd (Electrical Engineer, L.C.C. Tramways), said that in connection with certain large extensions for the Greenwich power house of the L.C.C. tramways, it became necessary to consider what to do with the air, whether to use the cloth or the spray system. In common with most engineers, he did not favour the idea of passing wet air into the generator, and he turned it down at first. He went to Brighton and saw the apparatus there was perfectly satisfactory, and it was now his opinion that this was the only way to filter air for generators. With a generator of 10,000 k.w. capacity running at 1,500 r.p.m. they had to deal with plant of very small size for its output, and occupying only about 1,000 cubic feet, and as this plant would lose anything from 400 to 500 k.w., it was obvious that this energy could not be dissipated unless an enormous amount of air was passed through it, and obviously air passing through small passages, must be cleaned and cooled. The best way to do this was by passing it through a washing stream of water. It might be necessary to pay £400 for a wet filter or £300 for a dry filter, but it did not matter which, when it was being put upon a plant costing £30,000, especially when it was considered that with air passing through a very cool stream of water there was a gain of 10 to 15 per cent. in the output of the generator. The extra cost, then, was not worth considering. He had looked at the two and was firmly convinced in the opinion, which was also shared by Mr. Fell, his chief, that the wet filter was the best, and as a result he was purchasing a plant capable of filtering 100,000 cubic feet of air per minute. This was, he believed, the largest plant of this description which has yet been ordered in this country. He had been disappointed at not hearing any data as regarded the amount of dirt to be dealt with in these large generators. He had made tests at Greenwich which was not a dirty station as regards air, although, perhaps not so clean as that at Brighton, and had found that the 10,000 k.w. machine, running the normal number of hours in the year, had to deal with something like 100 lbs. of fine impalpable dirt, which occupied a space of not less than 10 cubic feet and, obviously, if this were allowed to go into the machine, it would soon choke up the air passages, and without efficient air passages the machine would not run at all.

Dr. S. Z. de Ferranti thought there had been a certain amount of misconception underlying the idea of air washing for cooling electric generators. The last thing in the world he should have thought of would be to pass what was called wet air through an

electric generator. If it had been a question of wet air he did not think it would have got as far as it had done. With regard to the nature of the air going through, they might take a lesson from the Taylor-White air compressor which was being installed in some places in the United States, and more largely in Canada. If they had a river with a small fall and a very deep well adjoining it, water could be allowed to fall down the well and rise again by another shaft to a lower part of the river below a dam for example. With proper air entraining nozzles the water coming down the shaft took air with it, and the air was separated at the bottom of the shaft, the water passing out to the lower reaches of the river and compressed air being delivered as the product of this operation. It was found many years ago, almost before electric transmission was a practical thing, that this means of air compressing was very satisfactory for taking power from a river and sending it to some distance away to drive a cotton mill. He believed this was actually the first purpose to which it was put. The curious thing about it was that although it was compressed in a mass of water, the air was perfectly dry. Air compressed ordinarily by a piston compressor and then used in an engine gave considerable trouble in the way of freezing on expansion when its temperature dropped. This trouble was not experienced with the air compressed by this water method. The moral was very simple. If they wished to get rid of the infinitesimally small particles of moisture in the air which was called dampness, put that air into intimate contact with a big mass of water. That big mass of water would hold the small particles of moisture which was in the air, and then the air would be much drier than before it came into contact with the big mass of water. This was the root of the idea at the bottom of this successful method of air filtering and cooling which had been described by Mr. Christie. In this apparatus the essential feature was the screen which was at the end of the operation, i.e., where the air left to go to the alternator. That screen was a form of baffle and an essential feature of that baffle was to have it continually wetted by a considerable amount of down-flowing water. Once these principles were fully realised, the system ought to be accepted with confidence for ordinary working. Years ago large alternators and electric machines generally, were built with a few large cooling spaces between the iron round about the conductors. These machines, however, were very weighty and consequently too costly. One of the few good things that the lowest tender idea had done was to make people design their machines at a more saleable price so as to compete with their neighbours, and the effect of that was to reduce all the air spaces very much in dimensions and to get designers to put a much

larger number of them in. Then came the trouble of having these cheap, and for the moment more efficient machines silt up to such an extent that they became a danger, as it was never found possible to really properly clean the very hot places. He agreed with everything that had been said against the cloth filter, and he was only interested and surprised to see from the discussion that morning what good arguments could be brought forward to support a bad end. He had had a cloth filter on a 1,500 k.w. machine which took fire and very nearly caused the burning down of the station. Fortunately the particular machine was not at work, otherwise there would have been a very much worse accident. With regard to the workability of cloth filters, it was hard to call them crude and unsatisfactory because a lot of skill had been exercised in making them workable; but, nevertheless, they were a poor sort of thing, and notwithstanding the care that had been put into their design and manufacture, they were a makeshift sort of contrivance which could not be expected to endure. Even the first machine of the washer type that had been installed was eminently satisfactory. He had had one of these wet filters on a machine since September and had not known really that it had an air washer at all. It had been no trouble whatever. As regards cleaning, he knew practically nothing about this, because no cleaning had been necessary. Water did the washing and the thing went along working continuously night and day. The generator in question generated every day of the week about 70,000 units and there was no stopping for cleaning at all, so that in that way the thing was without history; it just stood there and did its work. With regard to freezing, there had been cold weather since the machine had been at work, but there had been no freezing on account of the very simple devices of opening the windows into the air washing chamber to the outside air, when the weather was warm or in case of the weather being very cold, they opened the door into the engine room which admitted comparatively warm air. What Mr. Christie had said with regard to increasing the output of the generator was perfectly right. He did not agree with the gentleman who represented the A.E.G. Co. that where there was a hot alternator—implying bad design on someone's part—that it was a good thing to put in a washer and cooler. As engineers, they had a certain amount of material to deal with in every case, and it was the engineers' business to get the maximum value out of it. If they had an alternator with a machine that cooled the air going into it, that good alternator was very much better, it had so much more output, or so much lower temperature, and consequently longer life.

Mr. C. H. Wordingham (Chief Electrical Engineer to the Admiralty) said it seemed to him that even if the air were fairly moist there was very little danger of it being deposited on the warm machine. He apprehended that they would not turn on the ventilation until the machine was fairly well loaded up. By that time it would be warm and he could not see what inducement there would be for the moisture to deposit itself on a warm machine. Dealing with Mr. Christie's remark as to the future switchboard containing thermometers and no other instruments he presumed this suggestion was made seriously, and personally he thought there was a great deal to be said for it, because after all the limit of the capacity of the machine was the temperature attained. It did not seem to him to be any drawback to this method that there was a lag between the rise of temperature and the load, so long as the temperature indicator followed the temperature without lag and the insulating materials of the machine were not allowed to attain a temperature at which they became damaged. Therefore, if they had what would ordinarily be a very heavy overload for a short time, so long as the thermometers did not show that the temperature of the machine had risen, it would be safe to allow the machine to take that overload even if it were enormously in excess of what it was thought the machine should do. The chief difficulty was to know how and where to measure the temperature of a machine. This was a thing that had baffled a good many people, and had never been satisfactorily solved. They could all measure the temperature of part of a machine but what was wanted was the maximum temperature of the machine or some part of it that they could not get at.

Mr. T. Roles (Chief Electrical Engineer, Bradford), said that the description of the cloth filters as an unsatisfactory makeshift was thoroughly justified. At Bradford he had cloth filters to deal with air going into three 3,000 k.w. turbo alternators, and he had come to the above opinion after twelve months' experience. In his opinion the cloth filter was crude, dirty and inefficient and a very expensive method of filtering air for turbo alternators and it was time that some other method was adopted in its place. He found that the cloth filters got so dirty that on an average they had to be replaced after one month's use at most seasons of the year. During the dry weather the cloths could be removed and the dust taken from them by beating or with a vacuum cleaner, but in the winter months when the usual air turned through the filter in Bradford had a humidity of

something between 90 and 95, the cloths got coated with what could almost be called a slime, and it was practically impossible to do anything but scrap the cloths. One of the speakers in the discussion had stated that cloth filters were simple and easy to clean. He should like him to try some of the Bradford cloths. The same gentleman also said that trouble might be anticipated with the water filter by reason of the galvanised iron rusting. Galvanised iron was generally used for building purposes to keep out the rain and it was also well-known that if galvanised iron was kept continually wet there was less rusting effect than if it were alternately wet and dry. Therefore he took it that the galvanised iron used in the water filters would not suffer as much as in ordinary use for building purposes where it was alternately wet and dry. In addition the same speaker had mentioned that it would be necessary to put a special pump with a man specially to look after it. In all their stations they had circulating pumps driven by motors, and he knew the degree of trouble there was in looking after such pumps. If a pump with motors from ½ h.p. to 3 h.p. gave all that trouble he would be very much surprised. As a result of the use of the cloth filters at Bradford—they had now been in use for twelve months and were the best thing he could get at the time—he was strongly of the opinion that it would pay his Committee to take the £300 to £500 that they cost and to replace them with a water filter. He added that he had discovered that even after the air had passed through the cloth filter it was not clean. On starting the filter up originally he put some cotton wool in the main air duct, and found that after two or three days this cotton wool was quite choked. There was no doubt that the heavy portions of the dirt were taken up by the cloth, but the smaller impalpable dust was taken through the interstices of the cloth and got into the machine. This was proved by the fact that if he passed his hand over the internal windings of the machine it was quite black, so that it was only a matter of time for the machines themselves to get equally dirty with the cloth filters in use as they would do without the filters at all.

Alderman Fred Smith (Chairman Liverpool Electricity Committee), asked if any one could furnish him with information as to whether it was a scientific fact that air agitated by a fan was purified in an inhabited, hermetically sealed chamber. He believed that an experiment of this sort had been carried out.

Mr. J. Christie in replying said after an experience of ten months he would not have any other type of filter in his station.

His previous cloth filter had been an endless source of trouble and expense to maintain, and it was also a very serious fire risk in his opinion. Several speakers had referred to the corrosion of the galvanised iron, but the iron was galvanised and when it was kept wet as Mr. Roles had pointed out, the corrosion was not excessive, while in addition it was a very simple and cheap portion of the apparatus to renew. With regard to pressure the filter he described in the paper was fitted to an old machine, and it was very difficult to get real data from it which would be of any service in laying out a new plant, but he was quite satisfied that the resistance to the air due to the spray was practically negligible, whereas with a cloth screen it started at about half an inch after the thing had been cleaned, and in four or five weeks it was up to 1½ inches. His suggestion for using a thermometer for gauging the load on the machines he hit upon when he visited Mr. Fedden's station, where there was a switchboard with a great number of push buttons, by pushing which it was possible to get a record of the temperature of everything in the station from the feed water to the flue gases, and it seemed to him that an extra switch would not hurt. He believed it would come in time. Mr. Clough had given useful formula for calculating for a minimum resistance. On this basis in his own case it would work out to be something like three megohms. He never got his insulation resistance below 15 to 20 megohms, and it kept quite steady. When he first started the filter it was on an old machine newly wound and the insulation was rather low. He dried it out and before putting it on load it came to about 12 megohms. After about ten days this gradually rose to 44 megohms and it remained at that. He then cleaned it, and put it on load with the water spray and the curve fell from 44 megohms to 18 and had remained at that ever since. Although it might rise and fall three or four megohms this was not sufficient to appreciably affect the machine. In replying to Alderman Smith's query, the answer was in the negative.

A hearty vote of thanks was accorded to Mr. Christie at the close of the discussion.

Electric Automobiles.

By WILLIAM H. L. WATSON and
RAYMOND J. MITCHELL.

Introduced by A. HUGH SEABROOK.

IN putting forward a *resumé* of some of the salient features of the electric automobile industry, the authors make no claim to original investigation, but rather in thus presenting some of the main facts relating to storage battery road traction, they hope interest will be aroused in a neglected subject. Many excuses could be adduced for the method of handling this subject, a method which may seem at the same time over-detailed, yet cursory. These defects of system are, however, inevitable in portraying the present stage of an industry that in Europe is uncoordinated, both as to its leaders and its venue of operations—whilst even in America, the natural home of battery traction schemes, it is but lately that a professional brotherhood of electric automobile engineers has come to pass. To this capable organisation, the Electric Vehicle Association of America, engineers should be grateful for the painstaking and thorough methods by which it has sought to foster an industry which the authors believe is destined to become one of the wonders of the twentieth century. A few words of definition are desirable at the outset—for there appears much confusion as to how the new road vehicle shall be named. At present it is equally correct to refer to

accumulator vehicles, storage battery cars, electric trucks, electromobiles and such combinations of these compounds as chance may decide. The generic term "Electrics" is eminently applicable to describe the whole class of storage battery propelled vehicles, the term, being already a currency in the United States, appears to be at least as justified as our commonly used word "'bus" for omnibus. Electrics will therefore be used as an inclusive term for both industrial machines and automobiles used for pleasure or passenger carrying purposes. The American industry in the building of electrics has already attained great importance. Altogether some forty companies are engaged in the actual manufacture of complete cars, and of these concerns, seven make both industrial and pleasure vehicles, whilst about a dozen plants confine their energies exclusively to the commercial type. Admitting that the electric is destined to invade or rather create new fields of usefulness for the automobile in many directions, it seems probable, however, that priority of importance will lie in the future with the industrial machine. A recent computation assesses the value of presently employed machines at a sum exceeding £12,000,000 sterling, which represents some twenty thousand cars. An approximate estimate of the energy required yearly by these cars, two-thirds of which are passenger cars, gives a demand of 65,000,000 k.w.h.'s; a quite respectable figure, which should nevertheless be centupled within the next ten years. A striking feature of the American industry in commercial electrics is that 70 per cent. of the sales of vehicles during the past two years were repeat orders from firms who, having started experimentally, had gained enough confidence to change over completely to electrics for their city transport. Many concerns hitherto employing horses had fought shy of the enormous expense attendant on the upkeep and operation of petrol-engined vehicles, distrusting therefore any type of motor transport. Such cases as these exist numerously in nearly all great cities, and will make steadfast friends for the electric when once the special advantages over other methods of traction have been realised. The Electric Vehicle Association of America has now several branches in

active operation, including one in Chicago and others pending in New England. This remarkably active Association is a tremendously powerful ally to the industry, and advertises on a large scale, having spent £20,000 already in publicity anent the electric vehicle. A large proportion of this fund was subscribed by electric power companies whose principals were alive to the importance of the charging load awaiting their stations. The Association holds monthly meetings at which papers are read on the more interesting aspects of the industry. Such contributions include not only scientific papers of the type of Mr. Alexander Churchward's essays on road resistance and the like, but also contributions of a purely commercial tone. All of which means that the Association is no academic body of merely philosophical enthusiasts, but rather an energetically determined body of men bent on pushing, and, moreover, forcing the electric into the front rank position they consider it should hold. British engineers might well copy America here, bearing in mind that just so soon as production exceeds demand, American manufacturers may start plans for an electric vehicle crusade in Great Britian. As a matter of fact, such a crusade would present fewer difficulties in this country than it must have met with in America. Roads are admittedly much better in Great Britain than in the States, labour costs are about half, whilst here, electrical energy is far cheaper. In view of these facts—facts which even a casual investigation will justify amply—the authors wish to express earnestly the sincere hope that British engineers and manufacturers will not allow the splendid opportunity which lies near to escape their observation merely because a few pessimists think "there's nothing in it." It is felt that no time was ever more opportune than now for a thorough discussion of the problems involved in the organisation of a British Electric Vehicle Industry. It is therefore hoped that all engineers present who hold views on this subject will take the present chance. We and many others here present will be interested to listen to all possible arguments for or against the movement. Very particularly interesting will be the views of central station engineers on the possibilities of supplying energy at special cheap rates for charging during

off-peak hours. Power at a low price is a *sine quâ non* for a really successful "electric" movement to become an actuality in Great Britain. Central station men are therefore interested most intimately in the new industry, which will be not only a branch of the motor-car business, but equally an expansion of the electric supply engineer's field of activities. This applies practically to every supply station in Great Britain.

General Considerations.

A survey of the electric vehicle field reveals the existence of more than a hundred and thirty separate models now available on the American market. Of these, about half are pleasure automobiles. Confining attention for the present to industrial vehicles, it is noticeable that this range of cars includes parcel vans of 300 lbs. capacity at one end and coal trucks carrying 10,000 lbs. at the other end of the list, with vehicles of graduated loadings above and below the limits stated. The table (I.) gives the average figures relating to the principal features of about sixty models of American industrial electrics. Included are the speeds recommended by the Electric Vehicle Association for various weights of chassis. These speeds were arrived at after very carefully considering all the limiting factors, both technical and commercial; they represent therefore the most economical practice. A careful perusal of Table II. will reveal considerable discrepancies from uniformity as regards the design of a truck for a given loading capacity. Thus amongst the 10,000 lb. vehicles there is a difference of a ton or so between the weights of the lightest and heaviest cars respectively. This represents an increase of about 25 per cent. in weight from the lightest vehicle to the heaviest—surely an indication that design is still in a state of flux, and that therefore now is the moment for us as a nation to take time by the forelock whilst the pioneers are also busy. We should then learn most rapidly and hasten on the time when our own products would be sufficiently perfected to deal with outside competition on a more equalised basis. It is also

TABLE I.

AVERAGE CHARACTERISTICS OF AMERICAN COMMERCIAL ELECTRICS IN 1913.

Loading capacity in lbs. ..	300	500	750	1,000	1,500	2,000	3,000	4,000	7,000	10,000
Vehicle weight in lbs.	2,200	2,650	3,000	3,450	3,500	4,300	4,700	6,000	8,500	10,850
Battery capacity in A.H. ..	150	150	150	150	150	225	225	300	375	450
Battery weight (lead) in lbs. ..	1,260	1,260	1,260	1,260	1,260	1,800	1,800	2,500	3,150	3,800
Battery weight (Edison) in lbs.	840	840	840	840	840	1,260	1,260	1,800	2,250	2,700
Average miles per charge ..	70–80	75	65	55	50	50	45	40	35	35
Maximum speeds on hard level asphalt in M.P.H.	20	17·5	16	15	14	11	10·5	10·0	8	6·5
Speeds recommended by Electric Vehicle Association in M.P.H.	20	20	16	13	11	10	9	8	7	6

NOTE.—Battery equipments are quoted *pro rata* of their average weight and capacity. Weights refer to chassis complete with *lead* battery, and bodywork.

noticeable that although a car to carry three hundred pounds weighs a ton yet one to haul a load of ten thousand pounds scales, as we have seen, only a little over four tons. That is, the ten thousand pounder weighs four times as much as the three hundred pounder; carrying thirty-three times the load for this increase. It then needs no comment or explanation for any business man to see that cheap ton mileage depends on employing fairly heavy trucks. This economical feature is of course not alone applicable to electric vehicles, a somewhat similar condition obtains with petrol machines, though nothing like so decidedly. American practice inclines to the two- or three-tonner for heavy haulage —using the lighter types of vehicles for services where very cheap ton mileage is of no account. For an extreme example the drapery business suffices. In such a case a very light car would be economical, and in fact all despatches of numerous packages of value can be most economically dealt with by the lighter vehicle. Heavy stuffs such as coal, cement, bricks and the like demand a truck big enough to deal with large quantities in one haul. These facts are shown in the accompanying graph, compiled from information derived over a period of ten years' continuous experience* with various sizes of electric truck. A glance at the curve shows that a ton mile done by the light delivery van—a 700 lb. vehicle—costs rather more than five times as much as the same duty performed by the five-tonner. The comparison assumes of course, that large amounts of merchandise are to be carried—and it follows therefore that for any given duty it is always cheaper to employ the smallest number of vehicles that the service permits. In handling coal as an instance, seven-ton trucks have proved themselves more economical than the higher speed two-tonners, for the reasons stated. Some reference to speed is desirable at this point. The casual critic, and unfortunately there are far too many engineers whose criticisms are *very* casual where this subject crops up, seeks generally to damn the electric by accusing the whole class of vehicles with deficient speed and inability to climb hills. Neither of these defects exists

* Compiled from statistics supplied by the Commonwealth Edison Company, Chicago, U.S.A.

in practice, though the electric does not claim the speed of its far more highly rated petrol competitor. Speed is purely a question of battery power and motor rating—and as commercial aspects towards engineering demand always a compromise, it is found the most economical to make the commercial electric a *moderate* speed vehicle able to maintain

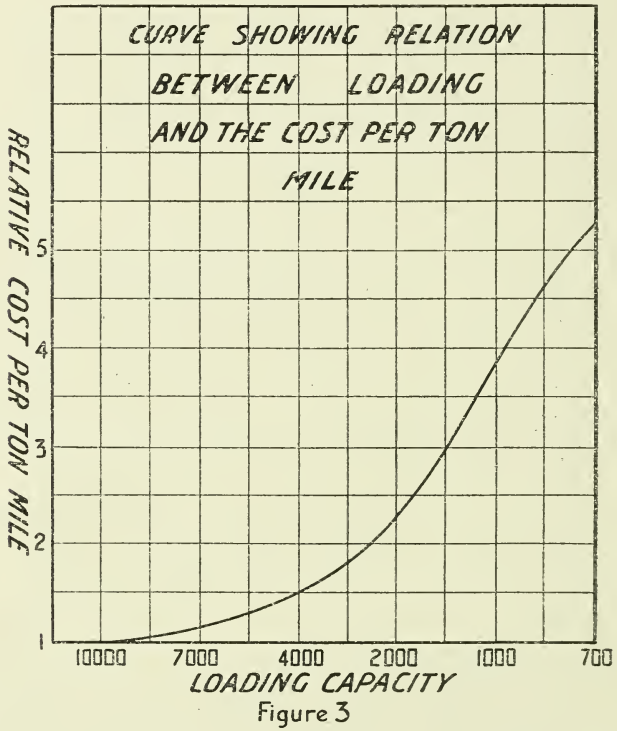


Figure 3

Curve shows comparative Results of Records kept carefully for 10 years by the Commonwealth Edison Company, of Chicago.

a *uniform* speed for a reasonable distance: This latter varying from thirty-five to seventy-five miles per single charge according to circumstances. Moderate and *uniform* speed means greatly decreased wear and tear on all parts of the chassis and transmission—including tyres, which are

usually guaranteed an extra twenty per cent. in mileage for use on battery cars. It is admitted that the inevitable straining which an automobile frame undergoes in service is roughly proportional in degree to the square of the maximum road speed. Hence it follows that frame distortion should be only a quarter as severe on a twelve mile an hour chassis

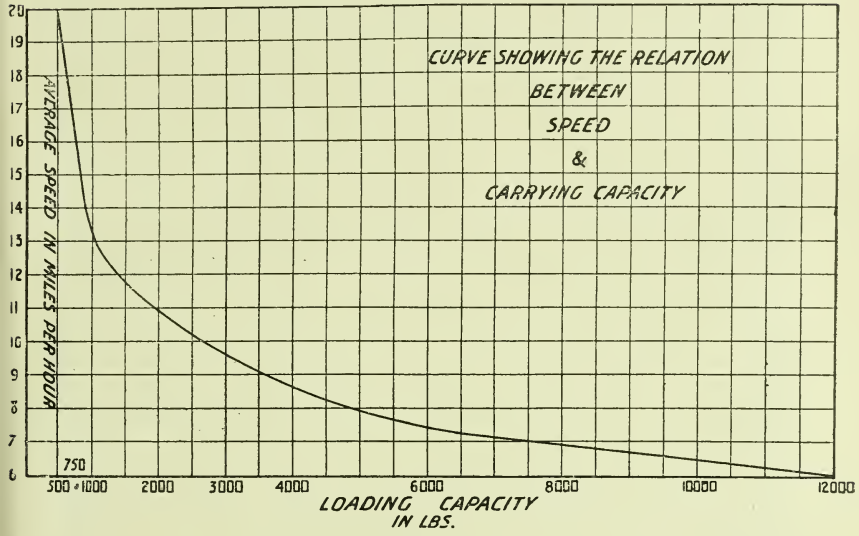


FIGURE 3a.

as it is in the case of a vehicle of which the higher limit of speed is twenty-five miles or more. This fact, together with the advantages of uniform torque on the road wheels and a complete absence of "snatching," such as occurs when clutch and gear box must be manipulated, make the electric the longest lived of all power road vehicles.

Already there are well authenticated cases of electrics having been in active commission for twelve years and still going well—for all their service. Although it is now usual to assess the life of these machines at ten years for depreciation purposes, there is little doubt that experience will prove

that this duration of usefulness will be far exceeded in actual practice. The mechanism of the battery vehicle is reduced to ideal simplicity—effecting the elimination of hundreds of parts, many of them reciprocating, and subjected therefore to rapidly alternating stresses. No such shocks as occur with a high speed engine can take place with the electric, excessive speed being possible only down hill. Neither can a driver of an electric damage his machine by racing home with the vehicle empty, as it is impossible to speed up beyond the limits originally imposed by the designer. On the speed question it is interesting to remember that the average point-to-point speed of a London motor omnibus is barely ten miles an hour—entailing an immense inefficiency in fuel consumption on account of the engine load being limited to a mere fraction of full power for such a high proportion of its road life. For traffic work there is little economy in operating a car capable of a speed greatly in excess of that of the average traffic stream. Therefore it is clear that moderate speed combined with a fairly uninterrupted progress is the condition at which to aim. The electric scores heavily on that heading, and contrary to the belief of many theorists, shows itself also well able to climb severe gradients. The authors have made many tests of the hill climbing abilities of a half ton van of Anderson manufacture—including the carrying of a load of 1½ tons weight from London to Portsmouth and much heavy work around Hampstead. Similar tests were made in the Newcastle district with complete success—many of the hills there have tested petrol-engined vans to their uttermost. The electric scores as a sure hill climber largely because of the valuable property of the series motor in that armature torque increases almost proportionally to the fall in speed, thus giving the necessary "drawbar pull" when it is most wanted. As a pure speed machine the electric is admittedly quite unlikely to compete successfully with present-day petrol automobiles. It is, however, interesting to note that a specially designed "Baker" electric has achieved the distance of one mile in a second less than a minute, its equipment including a 12 cell battery weighing three hundred pounds and a motor scaling only a hundred pounds. The

case should also be mentioned of another " Baker " machine which has a mile in 42 seconds to its credit—a purely experimental car of course. There might be a fair chance of an electric gaining a world's record for a one mile journey if anything useful seemed likely to be gained by the result. Just at present, however, far more important and practical matters claim the attention of the industry. A few more words on this matter of speed. The electric can accelerate more quickly than many other road vehicles. On a test made quite recently in the London streets, a six-ton battery 'bus showed an acceleration of 4·5 feet per second per second on the level—a figure 40 per cent. in excess of the average value of this factor applying to London omnibuses. Speed is of importance only to the extent of its effect in reducing *total cost per ton mile.* The electric has shown itself to be the cheapest land goods carrier extant, an indirect indication that moderate speed *is* most economical in the end.

If roads could be made uniformly hard and superficially unindented the speed question would be less worth mentioning, as it is admitted that air-resistance, the only remaining resistance factor of importance plays no important part in retarding moving vehicles until velocities above twenty miles an hour are attained. Granting that the electric achieves its economy of operation by a different method from that of the petrol vehicle and yet shows marked superiority in cost per ton mile handled there yet remains the necessity of dealing with the generally quoted objection that the battery car would be possible " if it were not for the battery." In the early days of battery car enterprise it was only too painfully true that nearly everything was fairly good excepting the accumulators, which were constructionally and commercially a miserable failure. Electrical engineers will doubtless recall that some of the earliest automobiles seen in this country were electrics. Particularly should be mentioned an electric carriage exhibited at the Stanley Cycle Show in 1896, the emancipation year of motor car users. This vehicle was amazingly " up-to-date," as it had a worm driven rear axle—one of the latest refinements of the modern machine ! Numerous schemes of battery road

traction have come and passed out of sight in the interim, but not out of mind—the schemes were too expensive for that. Amongst such enterprises must be placed the first London "taxis." The authors fear that many station engineers must have been shareholders in these early schemes, in which case they can understand more easily why so much pessimism remains to this day when storage batteries for traction are mentioned! The plain facts are that although it is still true that the lead sulphuric acid cell is an improvable device and the nickel alkali iron cell might with advantage be cheaper, yet there have been made enormous strides which place the accumulator on a quite definitely practical plane as an energy storer for automobile service. Later in this paper the authors will submit evidence in support of their already expressed confidence in the present-day storage battery. Meanwhile it is proposed to consider the modern electric under the various sub-divisions natural to the subject.

Accumulators.

Successful vehicle service entails batteries of the lightest possible construction consistent with durability and high specific energy output per pound. In the early days, plates of the pasted type were employed, mounted in an open containing case of ebonite. The output of such batteries hardly exceeded six watt hours per pound and was sometimes less, whilst their life was a little over a hundred complete cycles of charge and discharge. Considering that in the year 1900 a forty-four cell battery of 150 a.h. nominal capacity cost about £100, there is little wonder that electric automobile progress languished, at all events in England. The defects of early accumulators are so well known that any further mention of them is uninteresting. Beyond stating therefore that storage batteries appear to have proved what a chasm can separate ideal theory from even moderately good practical attainment, nothing more needs to be said. The vanished companies for battery car exploitation bear witness to some of the failures of the past. Lest it be assumed that the lead-sulphuric accumulator is still in its original

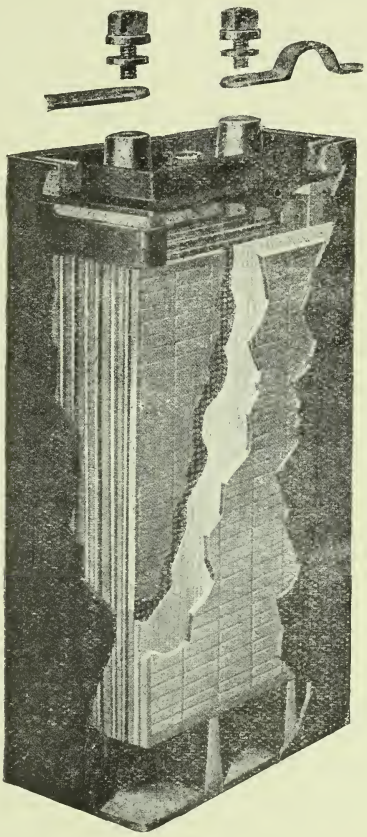
elementary state of crudity, let it be understood at once that quite the contrary is true. The modern electric vehicle accumulator, as developed largely by American engineers, is a triumph over mechanical and chemical disabilities which can only be paralleled in the early troubles of carbon glow-lamp manufacture. Improvements have become effected, not by any radical departure in design or revolutionary discovery, but rather because there has been applied every available bit of knowledge, mechanical, metallurgical, chemical, electrical that could coax such an unsatisfactory metal as lead into performing its dual function of resisting stress, yet giving sufficient surface for efficient energy output without undue weight. American storage battery engineers have tackled these problems with wonderful energy—and their reward must be admitted a success compared with former conditions. It remains to be seen to what extent the English manufacturer will follow the lead thus indicated.

Traction Accumulators.

For practical service there are but two types of storage battery in present day usage. These are the lead sulphuric acid cell—developed mechanically to a high degree of perfection considering the great difficulties of so doing—and the nickel iron alkali cell of which the Edison is the best known example. In the past, an immense amount of painstaking work has been done in an effort to discover other electrolytic couples which offered hopes of improving the accumulator on the score of lightness, durability, cheapness and the like. Nearly all these cells are forgotten, excepting perhaps the very interesting Waddell-Entz accumulator, using plates respectively of zinc and copper oxide in an electrolyte of potassium hydrate. This accumulator is mentioned by Mr. Wade as having been employed in tramway service both in New York and at Hagen in Germany and also in Vienna. The Waddell-Entz accumulator may be looked upon as the pioneer of practical alkaline cells—and was a remarkable achievement for that time—the year

1893. As has been already pointed out, the present-day lead accumulator dates back into very early days of electrical enterprise, Gaston Planté having devised the first cell, named after him, in the year 1860. The improved pasted plate of Henry Faure which appeared in 1881, marked the first practical stage of the traction accumulator and was followed by hundreds of patents for alleged improvements, many of them of remarkable ingenuity. The chief troubles of the lead battery in vehicle service are sulphating of plates on open circuit, and mechanical injury to them through either physical shock or internal stresses occasioned by the passage of heavy currents. Plate buckling is the most troublesome defect to overcome, and has occasioned more brain-racking than any other difficulty in this branch of manufacture. If any alloy could be discovered impervious to the action of sulphuric acid, and weighing even the same as lead but possessing ten times its strength, there would be immediate hopefulness in accumulator circles, and new positive plates would doubtless appear designed with rows of tubes, finely perforated to contain the active material. As matters stand, however, the modern vehicle battery is a compromise between lightness and durability. The usual plan is to make positive plates a little over an eighth of an inch thick and negatives somewhat thinner. The pasted type of plate finds most favour, though in some cases a specially light Planté plate has given good results, in spite of the greater weight entailed—a longer life making a small concession in weight more than justified. Spacing is arranged to be a minimum that considerations of electrolyte volume permit, whilst the specific gravity of the electrolyte is sometimes as high as 1·3. Separators of perforated sheet ebonite are often employed, fully encasing the positive plate in some instances. American practice also favours separators of specially impregnated thin wood sheets, these having proved cheaper than ebonite and equally effective. Celluloid has been found unreliable for traction accumulators, as it eventually becomes attacked by the strong acid. Considered as a mechanical job, the lead battery for automobiles has improved immensely. In place of the anciently used open container, a sealed-in case is nowadays employed, the top being liquid-tight yet removable. The

illustration (Fig. 4) shows a good example of modern vehicle battery practice. The terminals, container-lid, and general assembly of the cell will be seen at once to



Dissected View showing L.B.A. Automobile Battery of Willard Company's manufacture.

FIGURE 4.

be on the right lines. No splashing can take place, due to the special type of vent valve employed. Although there is a measurable difference between the performances of

various makes of storage cell, it may nevertheless be said that in every case a definite minimum life may be looked for. The actual figures for any condition of service seem to be dependent largely on circumstances. Thus there are some well-vouched-for instances where accumulators have given six or even seven thousand miles of running before becoming too much reduced in capacity for further economical service. On an average, it would apparently be true to assign a life of three or four thousand miles for a lead sulphuric battery in automobile service. A prominent English company running a fleet of private cars in London reckons usually to get three thousand miles life from positive plates whilst negatives last sometimes as long as six thousand miles. In this example the conditions are rather exacting as it is a common occurrence for the current demand to equal a one-hour discharge rating! The table (5) shows an American experience along these lines. It will be noticed that the pleasure car and lighter vehicles get more miles, but it should be remembered that heavier vehicles get more *ton miles* for a given capital expenditure on the battery. The value of these data lies rather in what they disprove than in what they prove. It is at least clear that accumulators have improved from those early days when a certain London electric cab concern found their cabs costing 32s. per day, and earning an average revenue of 23s.! This was caused mainly by battery defects:

TABLE 5.

Type of Vehicle.	Renewals in Positives.	Days in Use.	Total Miles Run.	Renewals in Negatives.
Pleasure car	3	335	7,310	—
1,000 lbs. van ..	2	253	7,962	—
1,000 ,, ,, ..	11	349	6,510	3
2,000 ,, ,, ..	1	349	8,854	—
2,000 ,, ,, ..	4	397	7,716	1
6,000 ,, truck ..	1	356	4,151	—
6,000 ,, ,, ..	2	336	4,027	—
10,000 ,, ,, ..	1	337	5,019	—
10,000 ,, ,, ..	2	342	3,670	—

No average figure can be stated for the useful life of a lead battery in traction work, as every peculiarity of the

service conditions entails some modification of the physical history of the plates. More clearly explained, it would appear that the very best results are gained by working a battery at as nearly its normal rating as practicable. Thus, it is less destructive to run a cell day after day under normal conditions than it would be to employ it occasionally at heavy rates of discharge followed by relatively long intervals of rest. Hence a greater ton mileage would be expected from batteries employed in commercial goods carrying or other heavy duty than in the far less uniform conditions of private service. The modern lead battery is remarkably compact and in average cases can store a watt hour for every cubic inch of the space occupied. This means that 2 h.p. hours can be delivered at the road wheels for each cubic feet of battery weighing on an average from 180 to 200 lbs. In exceptional cases these figures may be bettered, but those quoted represent the average of some twenty makers' practice. In emergency the lead battery will give a surprising power output for short periods. On a recent test of an exide battery, a momentary discharge rate equal to 75 h.p. was obtained from a battery weighing only 1,500 lbs. Hill climbing should therefore not present difficulties to the electric, and experience proves that such is the case. An improvement in the life of lead vehicle batteries has been effected in the so-called " Ironclad " battery. In this form the positive plate is composed of rows of ebonite tubes slotted vertically, and provided with a core of hard lead alloy—the space between being filled with paste. Although " Ironclad " batteries cost about twice as much as cells of the ordinary type, they do not appear to be as much better commercial or practical investment as was anticipated. Now and again rumours of other improvements in the lead battery go the rounds—the latest of these, due to H. I. Hannover, of Copenhagen, claims a discovery which is said to increase four-fold the specific output per pound of positive plate—a revolutionary improvement which it is hoped that time and practical working tests will justify. It is regretted that requests by the authors for the latest information made directly to accumulator manufacturers met with either complete refusal or silence. This attitude seems ill calculated

to foster either a spirit of mutual co-operation for the good of the electric vehicle industry, or unlikely to achieve that good-will always desirable amongst the personnel of any industry.

THE EDISON ACCUMULATOR.

The troubles which in many cases made the use of the lead battery uncommercial, in spite of its initial cheapness, led Mr. Edison many years ago to make very numerous experiments and trials of other electrolytic combinations than those hitherto employed. The central idea of Edison's work in this field appears to have been the elimination of sulphuric acid and the substitution of a mechanically strong material in plate of lead. Edison's first researches were therefore confined to alkaline-cum-metallic-oxide combinations of the type then in successful employment in the Edison-Lelande cell. Thousands of such couples were tried, resulting in the patenting of a cadmium-copper oxide cell in 1899–1900 working with a solution of potassium hydrate. The filing of a specification for this cell appears to have been a needless formality however, as the cadmium-copper-oxide combination was abandoned early in 1901 in favour of electrodes respectively of iron and nickel oxide. The cell of 1901 was the forerunner of the present-day Edison accumulator and passed through several modifications of mechanical construction before attaining its present-day form in 1908. The early faults were all mechanical, and manifested themselves only in the more severe services—actually there are still a few of the original pattern Edison accumulators in use which have been in service for ten years. The results obtained with this battery in vehicle service have been so uniformly excellent that it is hoped that the following description of the mechanical construction of the Edison battery will prove not uninteresting. All battery descriptions tend to centre round the positive or deplorising plate, and the Edison battery proves no exception to this rule, for the qualities which have already distinguished the new nickel-iron cell derive themselves almost entirely from the fact that it is impossible to dislodge

active material from this design of plate. Briefly, the method of loading the active material may be described as that of filling a small perforated steel tube in a series of thin layers, alternatively of nickel hydrate (green) and metallic nickel prepared in a finely-flaked form. The function of the nickel is purely one of conducting ; it being necessary to improve the rather poor conductance of nickel hydrate by making in the tube as many paths for the current as possible. Each steel tube is made from a thin strip of

Positive or Nickel Tube of Edison Accumulator.

FIGURE 6.

steel coiled around in a spiral of 0·25 inch diameter, the edges being lapped over to prevent re-opening ; which effect is further ensured by eight steel bands encircling the tube equidistantly. A complete positive element is composed of two rows, each of fifteen loaded tubes, assembled in a stamped frame of nickel steel, the complete unit having a

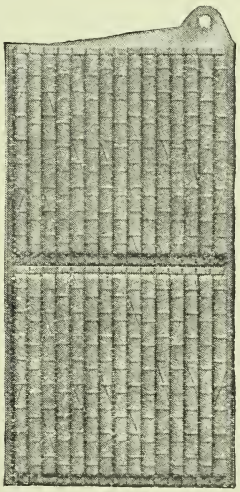
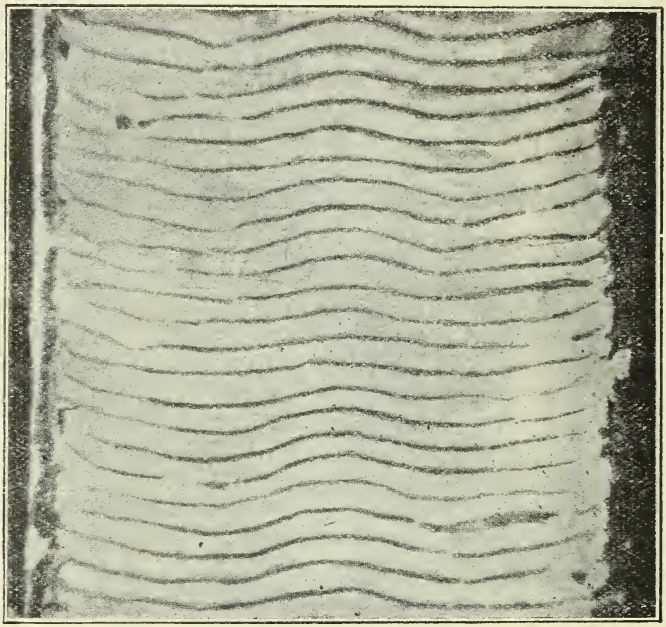


FIGURE 7. Edison Positive Plate.

deplorising capacity of some forty ampere hours. The illustration shows what a departure from ordinary constructional methods has been made, whilst the sectional



Microphotographic Sectional View of Edison Positive Tube, showing laminæ of Nickel Hydrate and Nickel flake. The nickel lines are darker.

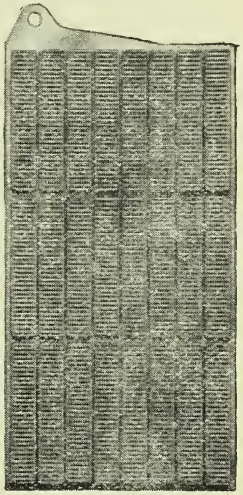
FIGURE 8.

micro-photograph illustrates clearly how uniformly the mechanical tube loading process is effected. The darker lines represent striæ of nickel flake. The Edison negative plate is of a form employed originally for both electrodes, but discarded later for positive plates in favour of the construction described already. Finely divided iron oxide, incorporated with a small proportion of mercury in order to reduce specific resistance, is loaded into rectangular

pockets made of very thin nickel steel strip finely perforated. Each pocket is assembled in a light steel retaining case and subjected to heavy die pressure, which has the threefold effect: (1) internally consolidating the active substance;

Negative or Iron Pocket of Edison Accumulator.

FIGURE 9.



Edison Negative Plate.

FIGURE 10.

(2) superficially corrugating the faces of the pockets, thus making them elastic yet rigid; and (3) swaging over the edges of the pockets so as to associate them effectively and permanently with the steel frame, making it impossible for vibration or shock to impair the conductivity of the assemblage, and therefore its mechanical unity. It might be doubted as to whether the presence of mercury in the iron would not tend to "rot" the thin material of the containing pockets. Such a defect however, proves to be not in the least existent. The assemblage of the Edison battery is also carried out on novel principles. A welded steel case replaces the more usually employed ebonite box—

this latter material being used for insulating purposes between adjacent plates (fine strips are found sufficient)—and to

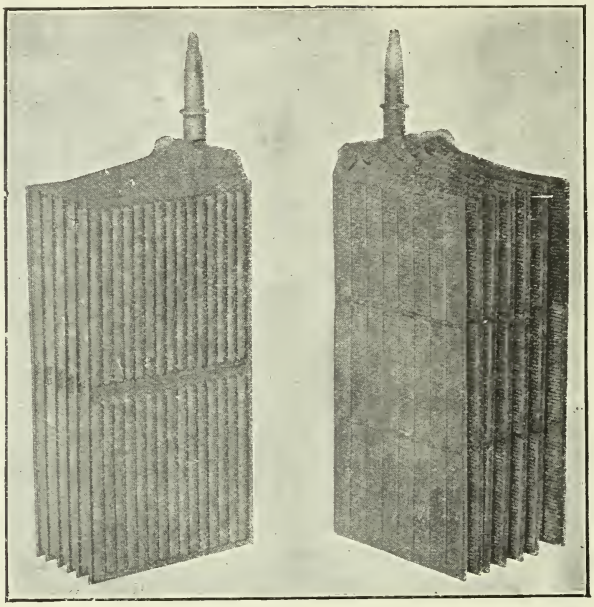
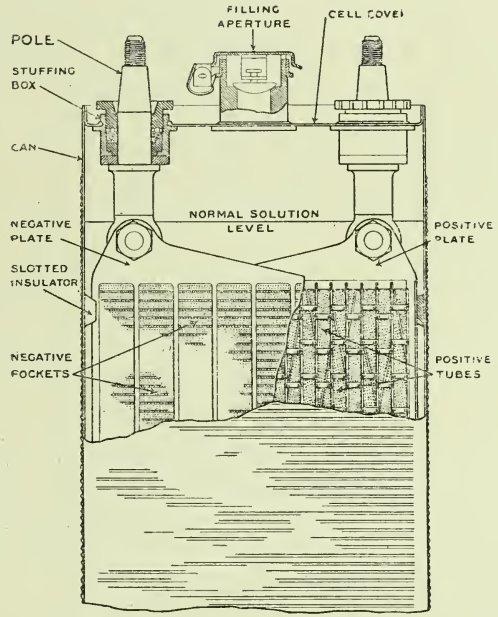


FIGURE 11.

prevent metallic contact between the plates and the case. Fig. 11 shows a group of elements before insertion into the container ; the tapered steel terminal post will be noticed with approval by the mechanically minded. The method of nickel plating adopted in the Edison works commands attention. An annealing process conducted in a hydrogen atmosphere at a red heat prevents the stripping-off effect which makes ordinary nickel plating so unreliable. When complete, each cell is watertight, protected from external ingress by a gravity valve which is incorporated in the snap-lid covering the filling aperture. An interesting feature of the electrolyte, a 21 per cent. solution of potassic hydrate, containing also lithium hydrate, lies in its now proved

preservative action on steel—hence terminal corrosion is impossible. Terminal leakage is prevented by surrounding the connecting bolts, of which the ends form terminals, by means of a stuffing box gland made of compressed paper which holds up to its work a soft rubber ring, on the same lines as a piston rod stuffing box. In designing the complete cell much care has been given to the mechanical



Internal View of Edison Accumulator.

FIGURE 12.

side of the problem. Thus it is rendered impossible for any relative movement or internal bumping to take place when a cell is shaken violently or vibrated. This property is obviously very important for vehicle service, where mechanical abuse has a far greater effect towards deteriorating

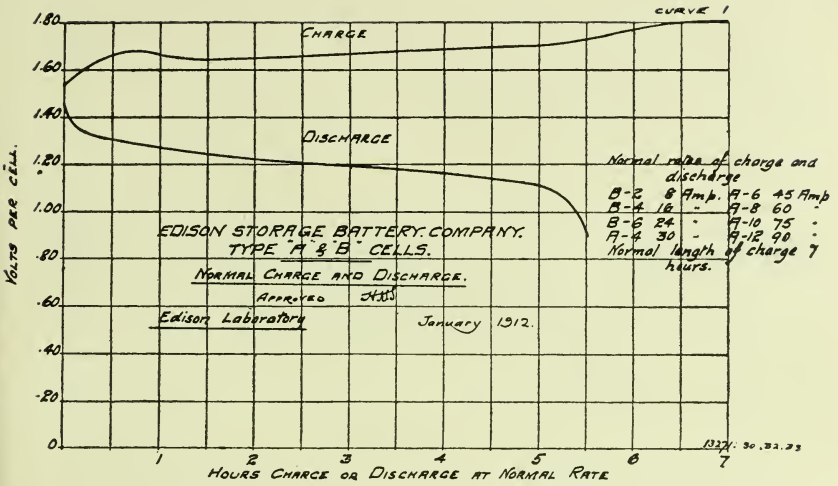
a battery than electrical " wear " can have. Very prolonged tests indicate that the Edison A type battery—the type that has now been going since 1908—possesses some unique features, chief of which are its nearly perfect immunity from the effects of mechanical abuse, the fact that no troubles such as plate buckling, nor shedding of active material can occur, and the absence of injury due to severe overcharging or discharging both as to duration and degree. Thus in some recent tests made in London, two traction cells were mounted on a shaking machine and dropped two million times a distance of three eighths of an inch, being shaken laterally at the same time. A careful examination of the cells at the conclusion of the trial showed that the loss in output was less than a quarter of one per cent., and that no mechanical injury whatever had taken place. The absence of sulphuric acid contained in an ebonite box is a considerable advantage for vehicle work, entailing greater reliability and the elimination of obnoxious fumes during charging, which are detrimental to men and metals. Before leaving this description, the method of mounting Edison cells in crates should have been mentioned. Due to the fact that the containers are metallic, it is obviously needful to prevent adjacent cells coming into contact. This is avoided by mounting each cell in a steel cradle supported in turn by a strong crate made of hardwood. The very strongly-made jumpers connecting adjacent terminals aid these devices for separation, which although entailing that an assembled battery occupies more space, are yet a most convenient expedient for preventing electrolytic injury to containers, and also serve the purpose of handling a large battery conveniently in easily liftable sections. In the course of their practical experience with the Edison battery, the makers have come across numerous instances where its extremely rugged design has stood in good stead against injury. Thus a battery which was involved in a garage fire, and had the whole of its electrolyte boiled away was found on being reassembled with new insulators to give an undiminished output. In another case, a vehicle battery had received nine hundred cycles of severe overcharge, yet remained unimpaired in output. Such instances could be multiplied.

The new nickel-iron cell is particularly adapted to services where charges can be effected only in an irregular manner. Thus on the Chesapeake and Ohio Railway, a battery car operates an average distance of two hundred and eighty-six miles per day mostly by boosting at heavy rates during terminal intervals, regular charging being confined to a five hour period during the night time. A tramway service in Washington is another good example of severe service conditions. A car running on a hilly route four miles long (maximum grade, 9 per cent.) averages two hundred and fifteen miles a day, charging being done at each end of the line in five minute periods only at five times normal rate. This installation is being doubled in length and will be operated on similar principles. Energetic gassing and high temperature have very little deteriorative effect on the Edison battery, hence its usefulness for such conditions. A great many theories have been put forward explaining the electrolytic action of this battery—none of them quite satisfactory. Whilst it is true that the action during discharge can be approximately explained as a transference of oxygen to the iron plate, which therefore becomes re-oxidised, the nickel plate meanwhile becoming reduced by the stream of hydrogen ions, yet this must only be accepted as a rough engineering approximation which leaves out of account much that is exceedingly puzzling to the electrochemist. For example, it is at present difficult by the ordinary methods of quantitative analysis to discover any difference between plates from a charged cell or one that is discharged ! It is quite possible that the future study of this question may prove to be as abstruse as that of the lead battery is well known to be. The tables and curves appended give some of the more interesting characteristics of Edison traction cells of various sizes from 150 a.h. to 450 a.h. nominal capacity per cell. In actual service the figures quoted will always be exceeded. An examination of these figures shows that the volume characteristic of this cell is 0·85 cubic foot per k.w.h. of available output, corresponding to an average weight of 75 lbs. The larger specific volume is partly accounted for by the necessity of spacing the cells as already described. In practical work, however, little difficulty arises on that

DATA APPLYING TO INDIVIDUAL EDISON CELLS.

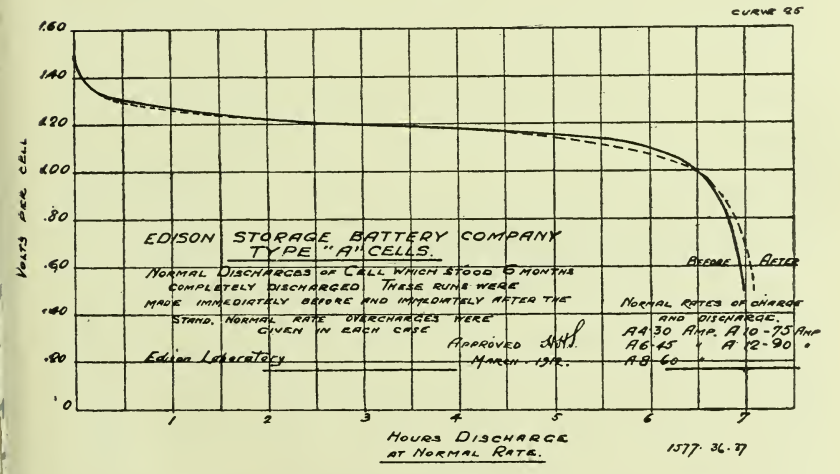
Type of Cell	B2	B4	B6	A4	A6	A8	A10	A12
Weight, in Pounds	4·6	7·4	10·5	13·5	19·2	27·5	34·0	41·0
Weight, ,, ,, including crate	5·5	8·7	11·8	15·0	21·0	30·3	37·5	45·0
Ampere-Hour Capacity—								
Rated Capacity, Ampère Hours	40	80	120	150	225	300	375	450
Normal Actual Output (7 hr. charge), Amp. Hours	42	84	126	168	252	363	420	504
Maximum Output on Overcharge, Amp. Hours	48	95	142	190	285	380	475	570
Watt-Hour Capacity—								
Rated Capacity, Watt Hours	48	96	144	180	270	360	450	540
Normal Actual Output (7 hr. charge), Watt Hours	50·4	101	151	202	302	403	504	605
Maximum Output on Overcharge, Watt Hours	57·0	114	171	228	342	456	570	684
Output Per Pound of Cell—								
Rated Capacity per pound, Watt Hours.	10·4	13·0	13·7	13·3	14·1	13·1	13·2	13·2
Normal Output ,, ,, (7 hr. charge), Watt Hrs.	11·0	13·6	14·4	15·0	15·7	14·7	14·8	14·8
Maximum Output ,, ,, Watt Hours	12·4	15·4	16·3	16·9	17·8	16·6	16·8	16·7
Discharge Rates—								
Normal (5 hour) Rate of Discharge, Ampères	8	16	24	30	45	60	75	90
Maximum Rate for Intermittent Discharge	50	100	140	180	225	300	350	400
Watt Equivalent of Normal Ampère Rate	9·6	19·2	28·8	36	54	72	90	108
,, ,, ,, Maximum ,, ,,	36	72	105	133	187	249	301	352
Average Voltage—								
Discharging at Normal (5 hour) Rate, Volts.	1·20	1·20	1·20	1·20	1·20	1·20	1·20	1·20
,, at $\frac{1}{5}$,, (25 ,,) ,, ,,	1·28	1·28	1·28	1·28	1·28	1·28	1·28	1·28
,, at 5 times ,, (1 ,,) ,, ,,	0·84	0·84	0·84	0·84	0·84	0·84	0·84	0·84
Internal Resistance—								
Mean Effective Internal Resistance, Ohms.	0·012	0·006	0·004	0·003	0·002	0·0015	0·0012	0·001
Electrical Efficiency—								
Normal Ampère-Hour Efficiency, Per Cent.	79	79	79	79	79	79	79	79
,, Watt-Hour ,, ,, ,,	60	60	60	60	60	60	60	60

Note.—*The ampère-hour capacity of an Edison Cell is practically constant at all discharge rates.*



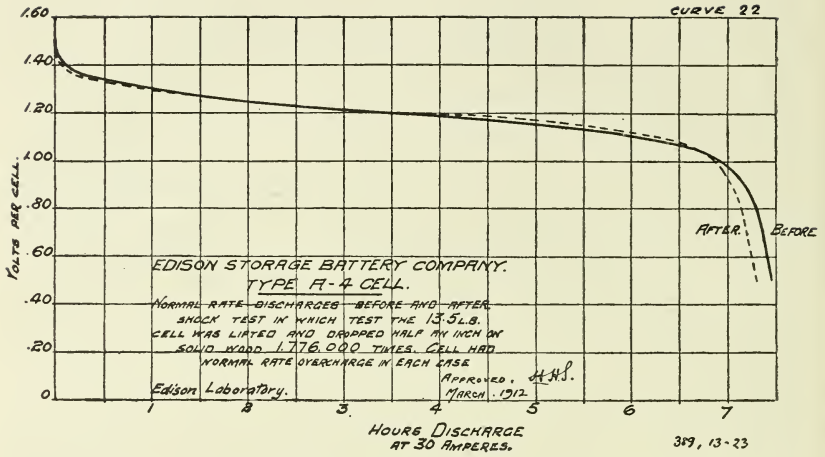
Typical Charge and Discharge Curve of Edison Cell.

FIGURE 13.



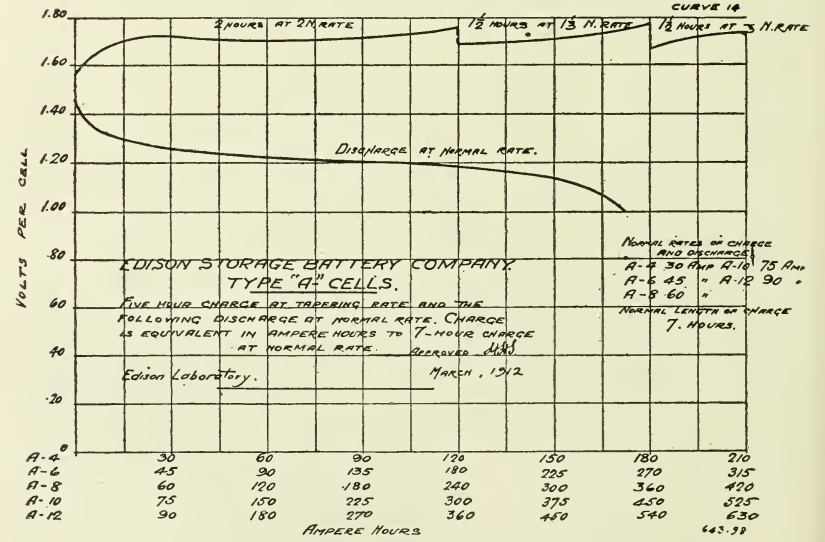
Showing effect on Edison Cell of standing idle for long periods.

FIGURE 14.



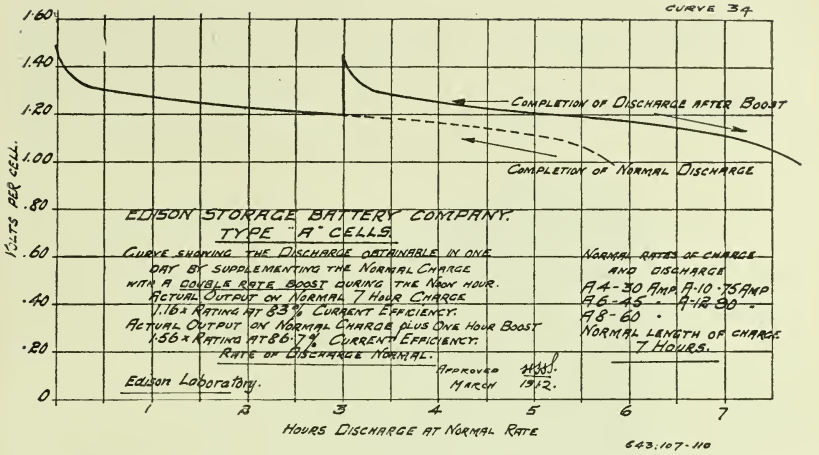
Showing small effects due to long continued shock test.

FIGURE 15


CURVE 14
VOLTS PER CELL.
1.80
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0
2 HOURS AT 2M RATE
1/2 HOURS AT 1/3 M. RATE
1/2 HOURS AT 1/5 M. RATE
DISCHARGE AT NORMAL RATE.
EDISON STORAGE BATTERY COMPANY.
TYPE "A" CELLS.
FIVE HOUR CHARGE AT TAPERING RATE AND THE FOLLOWING DISCHARGE AT NORMAL RATE. CHARGE IS EQUIVALENT IN AMPERE HOURS TO 7-HOUR CHARGE AT NORMAL RATE.
Edison Laboratory.
APPROVED H.H.S.
MARCH, 1912
NORMAL RATES OF CHARGE AND DISCHARGE.
A-4 30 AMP A-10 75 AMP
A-6 45 " A-12 90 "
A-8 60 "
NORMAL LENGTH OF CHARGE 7. HOURS.
A-4 30 60 90 120 150 180 210
A-6 45 90 135 180 225 270 315
A-8 60 120 180 240 300 360 420
A-10 75 150 225 300 375 450 525
A-12 90 180 270 360 450 540 630
AMPERE HOURS
643.38

Showing one method of quick rate charging of Edison Cell.

FIGURE 16.

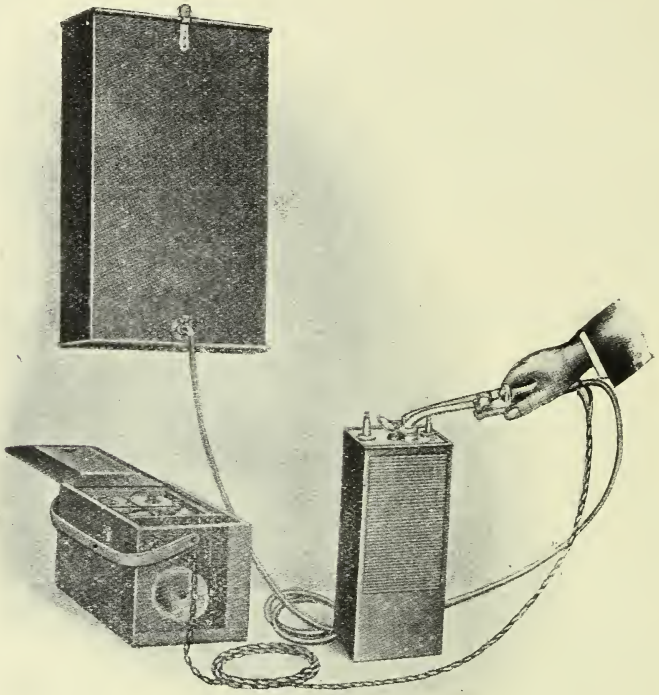

CURVE 34.
1.60
1.40
1.20
1.00
.80
.60
.40
.20
0
VOLTS PER CELL.
COMPLETION OF DISCHARGE AFTER BOOST
COMPLETION OF NORMAL DISCHARGE
EDISON STORAGE BATTERY COMPANY.
TYPE "A" CELLS.
CURVE SHOWING THE DISCHARGE OBTAINABLE IN ONE DAY BY SUPPLEMENTING THE NORMAL CHARGE WITH A DOUBLE RATE BOOST DURING THE NOON HOUR.
ACTUAL OUTPUT ON NORMAL 7 HOUR CHARGE
1.16 x RATING AT 83% CURRENT EFFICIENCY.
ACTUAL OUTPUT ON NORMAL CHARGE PLUS ONE HOUR BOOST
1.56 x RATING AT 86.7% CURRENT EFFICIENCY.
RATE OF DISCHARGE NORMAL.
Edison Laboratory.
APPROVED MARCH 1912.
NORMAL RATES OF CHARGE AND DISCHARGE
A 4-30 AMP. A-10 .75 AMP.
A 6-45 " A-12 90 "
A 8-60 "
NORMAL LENGTH OF CHARGE 7 HOURS.
1 2 3 4 5 6 7
HOURS DISCHARGE AT NORMAL RATE
643.107-110

Showing advantage of midday boost of Edison Cell in traction service.

FIGURE 17.

score, as the peculiarity can always be allowed for in the design of the vehicle. This battery is now guaranteed by its makers to show an undiminished output at the end of four years all day service in traction work. If used in stationary service the guarantee extends to six years. Evidently a battery which can uphold the terms of such a warranty will not fail immediately at the end of the four or six year periods. In fact, it is difficult to assign a probable duration to the life of this new cell, as the results of artificial ageing tests indicate a minimum period of ten years' all-day service without any renewals or repairs being necessary. In use, the Edison battery slowly appreciates in output, and it is no uncommon experience for a battery rated normally at 150 a.h. to give 180 a.h. in everyday service. Very high rate charging is permissible, and has not any detrimental effects if not carried on to an excessive degree. Thus in emergency, it is quite undetrimental to charge at five times normal rate for thirty minutes, although normal rate charging is more efficient than high rate " boosting " it is nevertheless exceedingly convenient under some conditions to be able to charge by the " boosting " method. For example,

in local delivery services from a large store, vans can take extra current during loading up intervals, thus augmenting appreciably their radius of useful action in a day's work. One little practical point should have received attention, the



Water-filling Apparatus for topping Edison Accumulators. A bell rings when electrolyte has reached correct level.

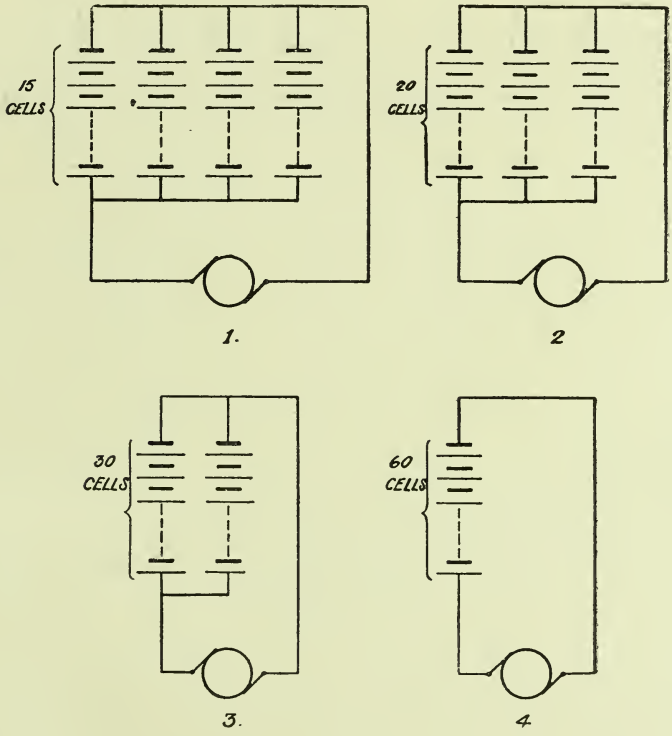
FIGURE 18.

method of "topping" up the Edison cell. This is done by means of a special filler which is arranged so that the correct level of the electrolyte effects an automatic index by ringing a small electric bell through a relay. Thus the difficulty of being unable to see inside the cells is obviated.

There are several other storage cells using an alkaline electrolyte now being tested in various part of Europe. None of these appear, however, to have been employed in electric automobile service, though doubtless the future may bring other steel cells into prominence.

Controllers, Controlling Systems, & Wiring.

At first sight there would appear to be no valid reason why an electric should not be controlled by variations of voltage



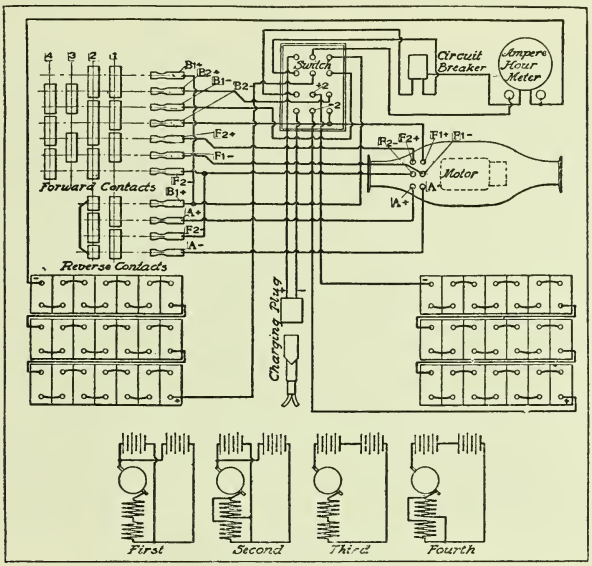
Showing Split-battery method of Speed Control

Figure 19

obtained by grouping the battery in successive arrangements of increasing voltage. This could apparently be done quite simply by dividing say, a sixty-cell battery into some such series as indicated in the sketches subjoined—whereby four voltages become available for speed control. Enticing as such a system appears, it yet proves to be rather complicated in practice, due to the large number of leads involved and the somewhat heavy currents which must be broken on the controller. Moreover, the last step is somewhat of a jump as compared with previous gradations, being inevitably a hundred per cent. increase over immediately previous voltage conditions. This would entail rather jerky running when changing from speed (3) to (4). Further objections to the pure-series parallel system of control lie in the effect of discharging batteries of the lead type in parallel—resulting in harmful inequalities of discharge towards the end of the output. With a lead battery this treatment may cause injurious sulphating, and a not uniform behaviour of the cells as a whole. The objection, however, has no weight in the case of nickel-iron cells of the Edison type, as these cells are quite unaffected by arduous discharge conditions amounting to short circuiting on the one hand, or being left on open circuit for indefinite periods. From the efficiency standpoint the series-parellel method of control is much in advance of the systems using resistances which have displaced it, and future practice might reinstate the system with considerable advantage, if mechanical difficulties be overcome. Modern vehicle motor controllers are mostly of the continuous torque drum type, operated by a lever, geared up in its effect by meshing with a small spur pinion on the drum shaft. Usually a series of five or six speeds is provided—the highest being that obtainable with full battery voltage across the motor together with a field partially shunted by a resistance of the iron-grid type. With a few exceptions, the springiness of the contact fingers is relied upon to give an adequate contact on the drum sectors—the current being broken on the drum itself. This is not the best practice, and could be much improved by arranging to operate a carbon break switch immediately after a drum contact has been ruptured. Another method—actually

used on one car—effects the same result by using a magnetic " blow-out " coil, the field of which " wipes " out injurious arcing. The figure gives one method of speed control which may be regarded as typical of average practice—the small serial drawings will make the system self-explanatory.

As a rule the controller handle is operated in a horizontal plane underneath the steering-wheel, a press button being



Typical Controller-circuit Diagram of Vehicle Motor. Battery in parallel on first two speeds.

FIGURE 20.

incorporated on the end of the handle to actuate an electric warning signal. Other refinements include the automatic breaking of the current when putting on the emergency brake, which latter, particularly on commercial vehicles, is interlocked with the controller. The illustration shows a

good example of such a controller. Yet another modification employs solenoid contactors of the railway type to operate the controller. This design, providing a very high degree of care be exercised in its installation, should have a considerable vogue in the future. It would be a distinct gain to be able to operate a 5 ton truck by push button electrical control. Electric breaking does not appear to find favour in American practice though one English car, the well-known Electromobile, uses such a brake for emergency service. If designed so as to retard the car gently—that is

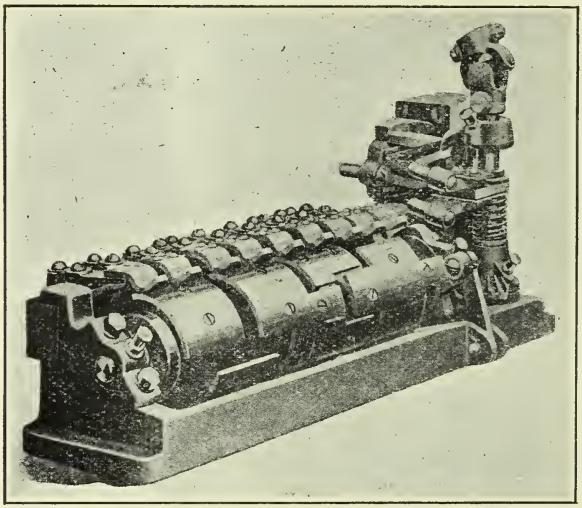


FIGURE 21. External View of Anderson Controller and Reversing Switch.

not to skid the driving wheels,—there is much to be said in favour of electric braking, as it is less severe in its action and wears nothing out. A useful refinement to a controller consists in arranging that an electric bell shall ring if the current be left on when the brake is also in the hard-on position. This is more necessary than may appear at sight, as it is quite easy for a careless driver to leave his controller in the first notch (generally insufficient to move the car with the brake on)—thus wasting much energy and perhaps doing

great damage. Charging plugs were the occasion of much confusion and waste of time in the earlier days of the American industry. This matter should, in the opinion of the authors, be discussed in England as early as possible by those interested. Much trouble afterwards would be saved by the adoption of a soundly designed plug right from the beginning of the movement. The electric automobile, whether pleasure car or commercial, presents some special problems of its own

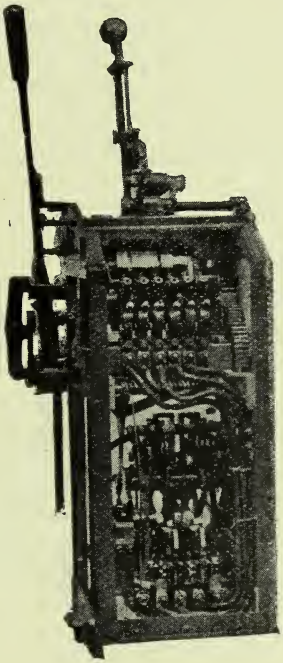


FIGURE 21a. Silvertown Interlocked type of Controller.

on the score of lighting equipment. The usual arrangement consists in taking leads from a few cells of the power battery, relying on the gradual voltage drop not proving great enough to dim the lights seriously. In American practice some difficulty is occasioned by the lack of standardisation in bulb sockets—this difficulty would be much smaller in England however. A voltage of six with Osram or other metal

filament lamps gives a good range of candle powers in stock bulbs and such lamps are very cheap. It is a good plan to put the rear lamp in series with a small coloured bulb illuminating the ampere hour meter on the dash-board. Reference should be made here to the use of the ampere hour meter. This device has attained much perfection and convenience of form mainly at the hands of the Sangamo Electric Company. Such an instrument replaces the ampère meter and volt meter if used discriminatingly, at the same

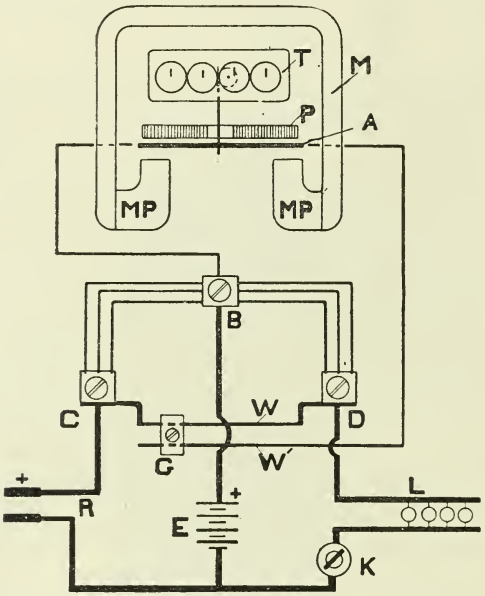
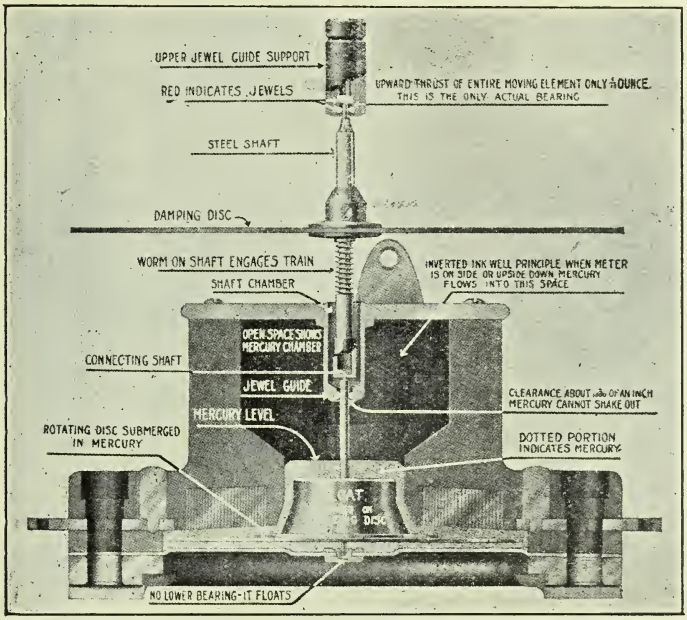


FIGURE 22.

time affording a more accurate index of the battery performance. The illustration (Fig. 24) shows the exterior view of a Sangamo Meter from which it will be apparent that the single pointer large diameter dial affords a very conveniently readable device. In one type—the best in the author's opinion—there is a differentially shunted circuit which ensures that ampère hour readings shall be a true measure of battery output and shall measure effective battery

in-put, that is, *allowing for battery efficiency*. Thus 85 amperes for one hour would register an output of 85, but to register an input of 75 ampère hours would probably *require* 100 *ampère hours*. If the instrument be set to allow for necessary battery inefficiency it may then be used practically as a reversible energy meter. This applies especially to the Edison Battery in which it happens that ampère hour

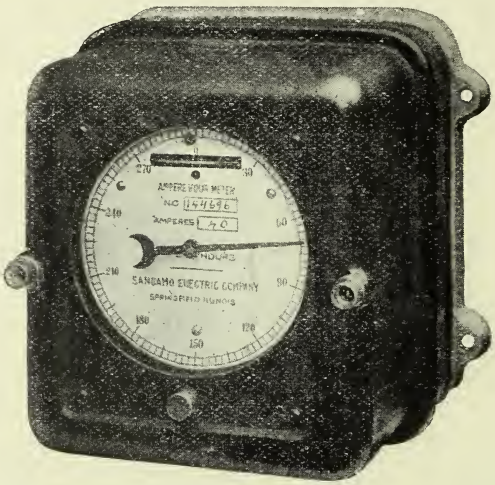

UPPER JEWEL GUIDE SUPPORT
RED INDICATES JEWELS
UPWARD THRUST OF ENTIRE MOVING ELEMENT ONLY 1/4 OUNCE. THIS IS THE ONLY ACTUAL BEARING
STEEL SHAFT
DAMPING DISC
WORM ON SHAFT ENGAGES TRAIN
SHAFT CHAMBER
INVERTED INK WELL PRINCIPLE WHEN METER IS ON SIDE OR UPSIDE DOWN MERCURY FLOWS INTO THIS SPACE
OPEN SPACE SHOWS MERCURY CHAMBER
CONNECTING SHAFT
JEWEL GUIDE
MERCURY LEVEL
CLEARANCE ABOUT 1/100 OF AN INCH MERCURY CANNOT SHAKE OUT
ROTATING DISC SUBMERGED IN MERCURY
DOTTED PORTION INDICATES MERCURY
DISC
NO LOWER BEARING-IT FLOATS

Sectional View showing Interior Arrangement of Sangamo Ampère-Hour Meter,

FIGURE 23.

output is hardly affected by rate of discharge. An interior view of the ampere meter is given, from which it will be recognised as a damped mercury motor of which the speed is nearly proportional to the value of the current passing. The diagrammatic drawing shows the principle of the Sangamo instrument. As the wiring arrangements on a modern electric are necessarily somewhat complicated, it is

therefore desirable to bestow on detail work herewith associated the greatest thoroughness and care in making certain that neither vibration nor acid fumes have any detrimental effects. In some cases the American manufacfacturer appears hardly careful enough on this score. Where a little more expense of time, both in the drawing office and works, would be such an excellent investment there is no excuse for its omission.



External View of Ampère-Hour Meter for Electric Automobile.
FIGURE 24.

TRANSMISSIONS.

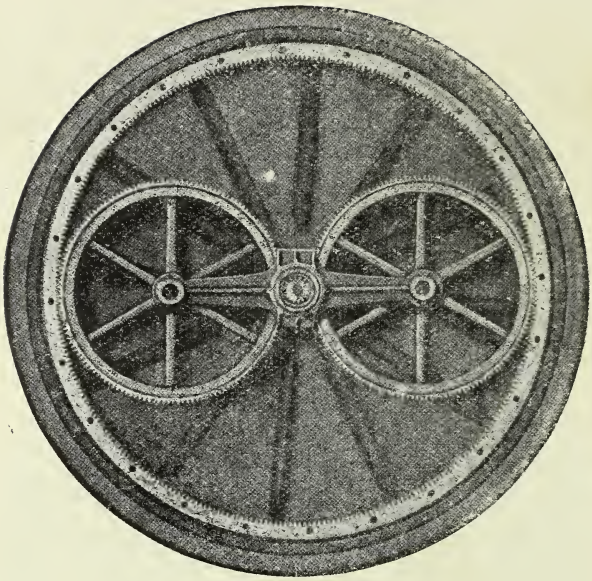
The electric automobile has induced its own special designs for the economical transmission of power as well as having used a few old systems, well-known by engineers to represent improvable practice. Perhaps the simplest of all transmissions is that employed in the Cedes motor wheel—a design which originated some years ago in the Mercédès petrol-electric automobile. Not proving an unqualified success in its first application it took on a new lease of existence in the now well-known Cedes electric car and has done useful work both for ambulance and fire brigade work in

the City of London. The photograph shows the salient features of the motor wheel. The motor is of the distributed-field multipolar type. Some of these wheels are stated to have travelled 100,000 miles without appreciable depreciation taking place. They are completely closed against water and dust. There are several so-called wheel drives to the credit of American designers, notably the Walker, Commercial and

View of Cedes Electric Motor Wheel with outer cover removed.

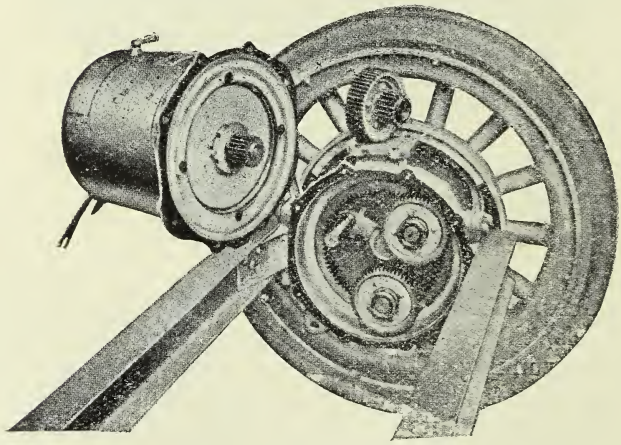
FIGURE 25.

Couple-Gear. The Walker gear uses a single motor to drive two wheels, the actual drive being transmitted by an epicyclic gear running in oil. The Commercial Gear is another departure from traditional lines, each wheel having a separate motor transmitting its torque through a double reduction epicyclic gear to an internally cut ring similar to the Walker.



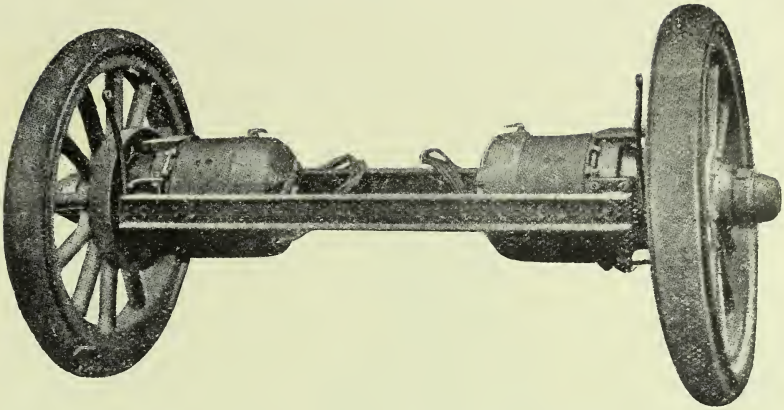
Internal Gear Wheel Transmission on Walker Company's Car. Motor is concentric with central spur-pinion.

FIGURE 26.

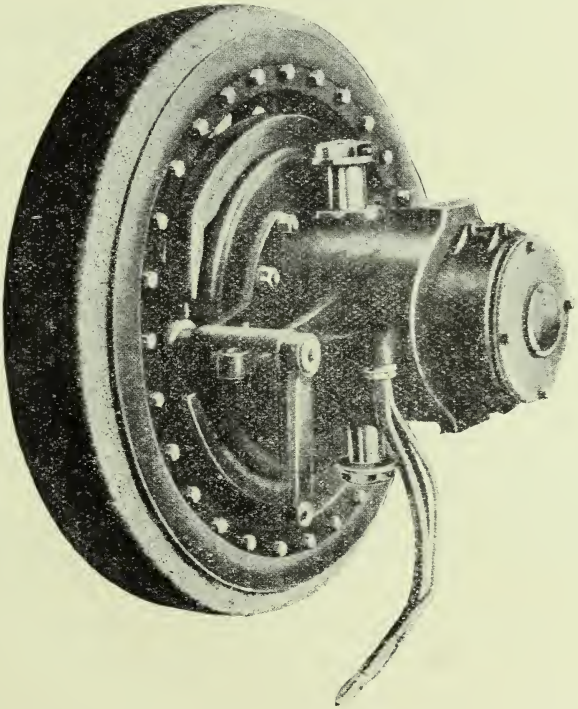


Details of Commercial Company's Epicyclic Transmission Gear.

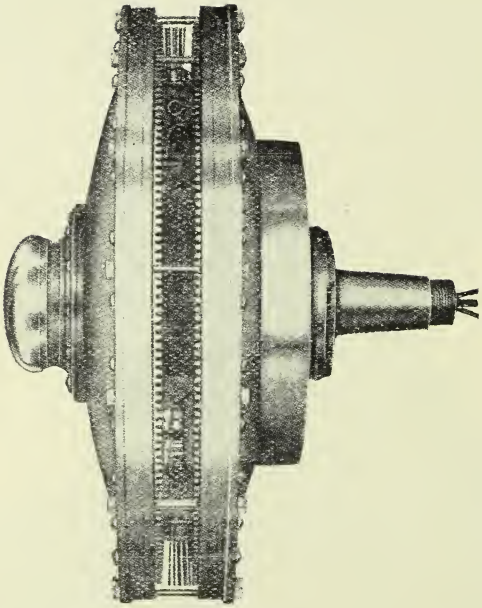
FIGURE 27.



Two-motor Driven Axle of Commercial Company
FIGURE 28.



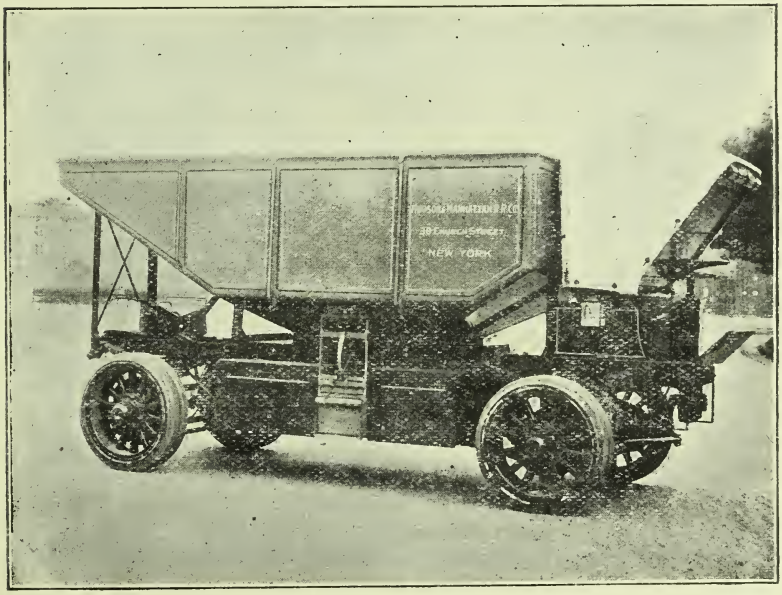
Assembly view of Commercial Company's Motor-wheel Heavy Front-driven Machines
FIGURE 29.



Couple-gear electro-motor wheel showing method of double pinion gearing to geared rings on wheel. Motor is fixed and rotates wheel. Reduction 1 to 25. Rim and tyre removed.

FIGURE 29A.

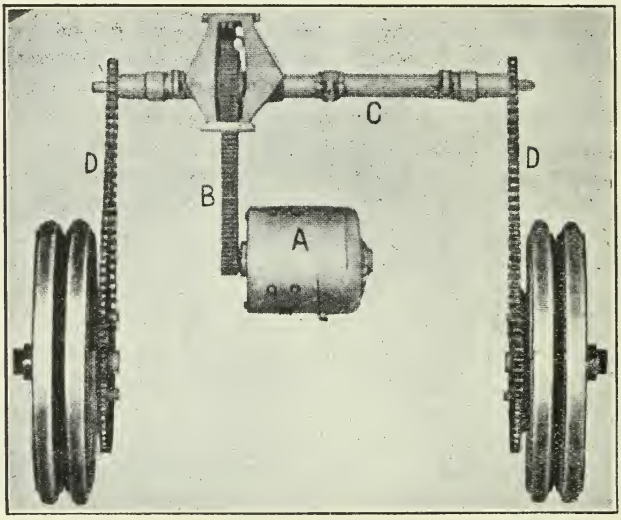
In the Couple-Gear motor wheel, each wheel encloses a motor, the shaft of which engages by means of small bevel pinions with two parallel bevel rings, one pinion with one ring, the other with the second ring. This drive claims to be perhaps the most efficient mechanical drive extant—an efficiency of 97.5 per cent. being vouched for by the American Bureau of Standards. Thus a reduction of 25-1 is made possible. The illustrations will make this interesting trio quite understandable. The special advantage of wheel drive lies in its being possible to apply four-wheel drive or simply *front* wheel drive to some machines. Front wheel drive reduces the skidding nuisance, whilst four-wheel drive has proved econo.nical for heavy machines carrying five tons and above. A special machine driven on all four wheels is shown on the view of the seven-ton coal



Electric Truck of 7 tons capacity for Handling Coal. Four-wheel drive. Edison Battery 60 cells A12. Capacity 36 K.W.H.

FIGURE 30.

waggon appended. This type of electric will in the future find a considerable field of usefulness before it. It can do 300 ton miles in a working day of eight hours on a battery input of not more than 0.18 unit per ton mile. Double chain drive is at present almost universal on commercial electrics, the first reduction being effected by a silent chain of the inverted tooth type. Final drive is usually by unenclosed roller chain—a device which though reasonably efficient

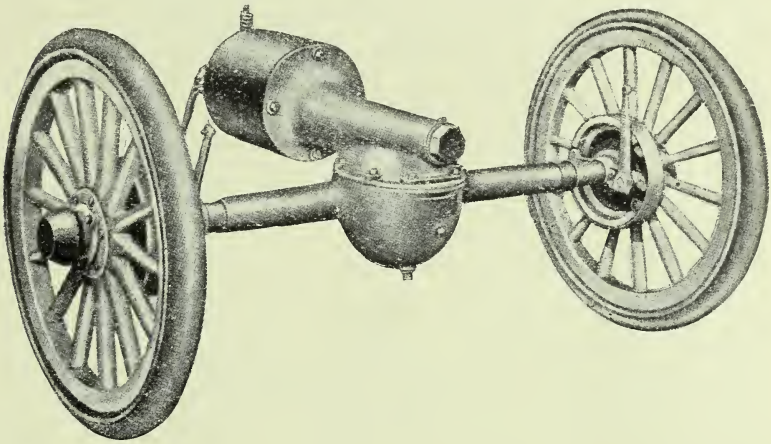


Showing simplicity of Transmission on Commercial Electric. A—Motor. B—Morse Silent Chain. C—Differential Countershaft. D—Final Drive by Renold Roller Chain.

FIGURE 31.

when kept scrupulously clean and oiled, seems likely, at all events for heavy machines, to be superseded by some of the previously described systems. A praiseworthy tendency for light transmission is shown in the Commercial light rear axle, a totally enclosed rear axle and motor in one unit, the drive being by a Hindley worm gear. Many engineers have

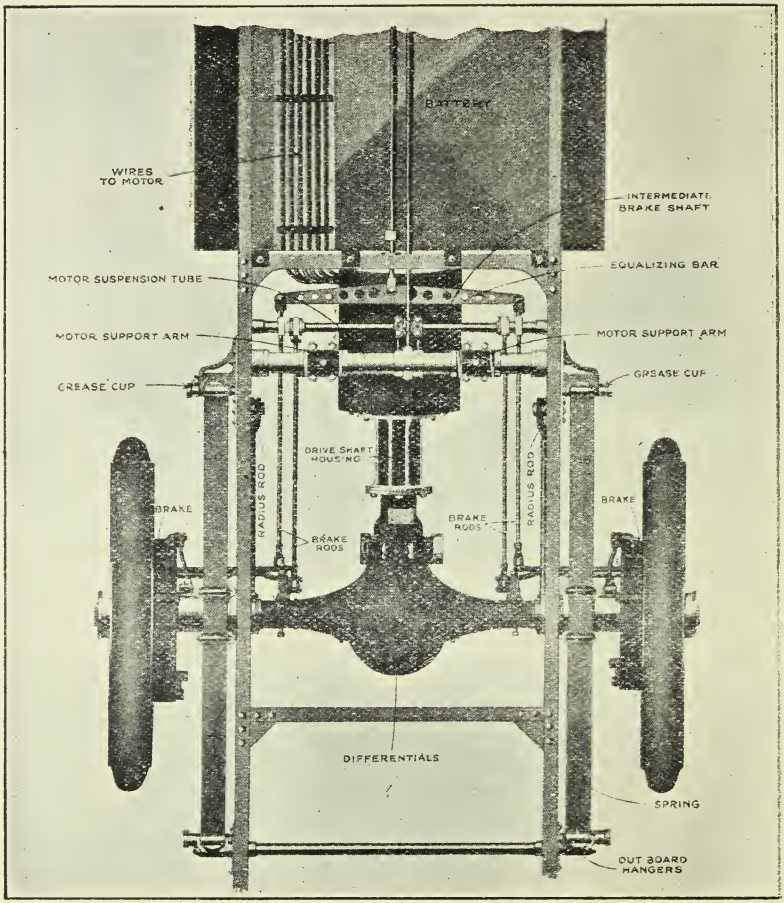
doubted the efficiency of the worm gear as a transmitter of power—but their doubting state of mind seems no longer justifiable, as Mr. Lanchester's researches have now proved beyond cavil that a carefully designed worm gear will give high efficiency maintained for many years uninterrupted running. Designers of electric automobiles, whether for pleasure use or commercial, should strive to make transmission efficiency as nearly perfect as possible; the open



Single Unit construction of Commercial Company's Rear Axle. Motor drives overhead worm-gear, and is spring borne at rear. Construction suitable for light high-speed Delivery Van.

FIGURE 32.

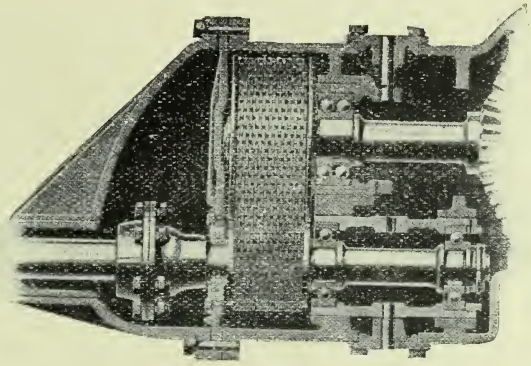
chain is not perfect. A good design for a medium weight commercial car transmission is shown in the plan view of the Buffalo Company's two-ton vehicle herewith illustrated. The rear axle and motor are integral with one another, the rear axle being permitted vertical motion by the expedient of suspending the motor on trunnions pendulum fashion. Amongst the pleasure cars, very few retain the chain drive, and only one uses the worm gear. The Baker reduction gear is a very careful job, the first reduction being by silent chain.



Buffalo Company's Transmission Arrangement. Motor suspended on overhead brackets.

FIGURE 33.

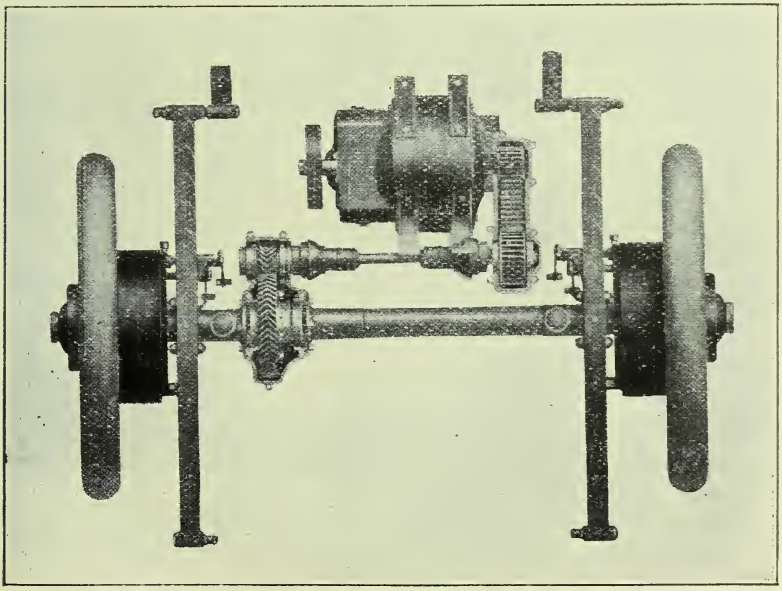
This make of electric is one of the oldest. Another method of gearing—the Waverley—is noticeable. In this case a



Internal View of Two-step Reduction gear on Baker Rear-axle.

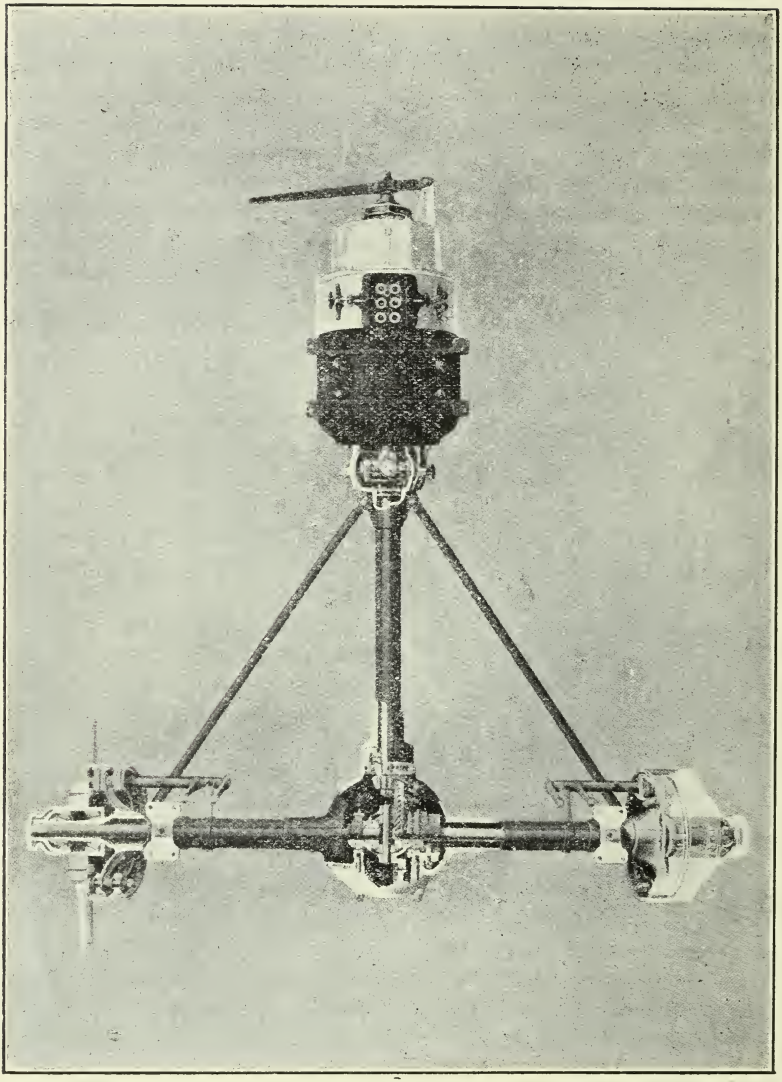
FIGURE 34.

silent chain gives the first reduction, final drive being by double herring-bone helical gear. A very high efficiency is



View of Double-reduction gear of Waverley Electric Pleasure Automobile.

FIGURE 35.

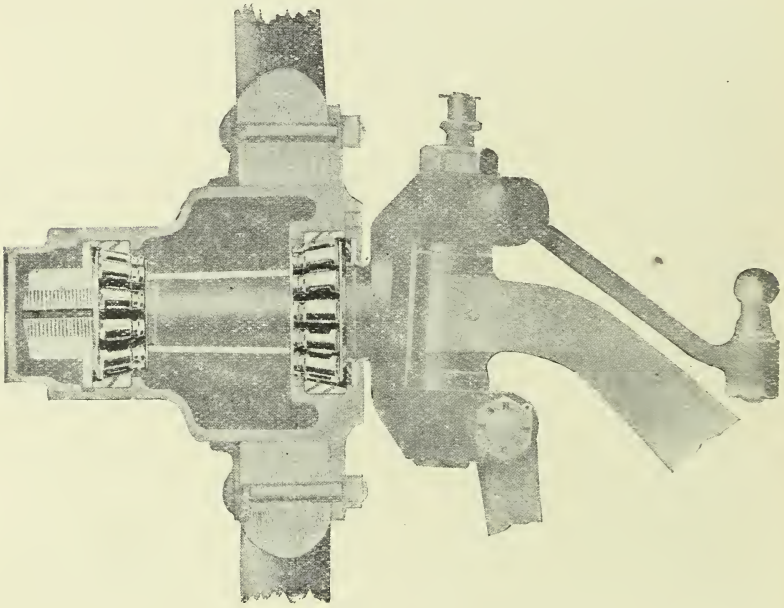


Single Unit Transmission of Anderson Electric Car.

FIGURE 36.

claimed for this system. A good example of reduction effected in a single step is that of the Anderson, the neat axle and torque table of which are shown. One maker of pleasure electric, the Church-Field, employed a planetary gear on the transmission shaft, the low speed being geared down. The advantages claimed for this device are reduced current consumption uphill and increased speed. It therefore follows that motor efficiency is higher on account of reducing the heating losses—and the battery life should be longer also. The introduction of a gear in the line shaft of an electric may be against sentiment, but there appears to be nevertheless a good case for its adoption, unless some improved motor can eliminate the present inefficiencies inevitable at very low speeds. Quite a remarkable feature of the transmission design of electrics is that no two makers' systems are alike, and this applies to Europe as well as America. For example, the Kreiger, the Electromobile, Lloyd, and Bergman machines are distinctly different —the Kreiger being a two-motor front-driven car. Doubtless some order will settle out from the present chaos of design—greatly to the ultimate improvement of mechanical efficiency. Ball bearings find a special utility on the electric and prove very durable for such locations as countershafts. For heavy loads the roller bearing of the Timken type has proved itself superior: as this bearing can be adjusted to compensate for wear. The most desirable features of transmission gear on an electric are high mechanical efficiency maintained even at very heavy loads, low speeds, and after long service—and simple durable design. The advent of the electric automobile came in time to test what the mechanical engineer could do at his very best. The electric can only be a success if made superlatively well—and therefore a "cheap" car of this class is unlikely to appear. The "cheap" car disguises its inadequacy under high speed which covers for a time *very low ton mileage* per shilling's worth of fuel. This defect in an electric would be the very worst. Taken altogether there seems no good reason for employing any form of transmission on an electric that is not (1) totally enclosed; (2) running constantly in oil; (3) made superlatively well both as to design, workmanship

and material. It should be remembered that to-day the designer of electrics has at his disposal mechanical features that are practically perfect—bearings that absorb a mere percentage of power, motors that are of their kind electrically unimprovable, gears that are noiseless and almost proof against wear. Hence the assertion now often made that an electric automobile should give fifteen years' service without serious deterioration of mechanical efficiency.

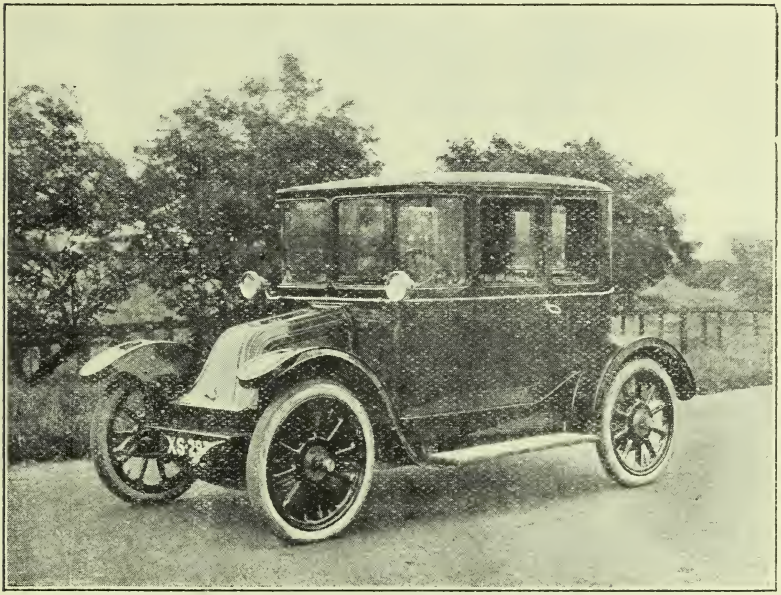


Internal View, showing Timken Roller-Bearings applied to front wheel of Automobile.

FIGURE 37.

SOME FEATURES OF ELECTRIC VEHICLE DESIGN.

The pioneer electrics were as lacking in detail perfection as they have since become refined and advanced. For some not very obvious reason these machines were made disproportionately heavy and in the case of pleasure cars were equipped with bodies, the great ugliness of which has created a widespread impression that the electric must necessarily be

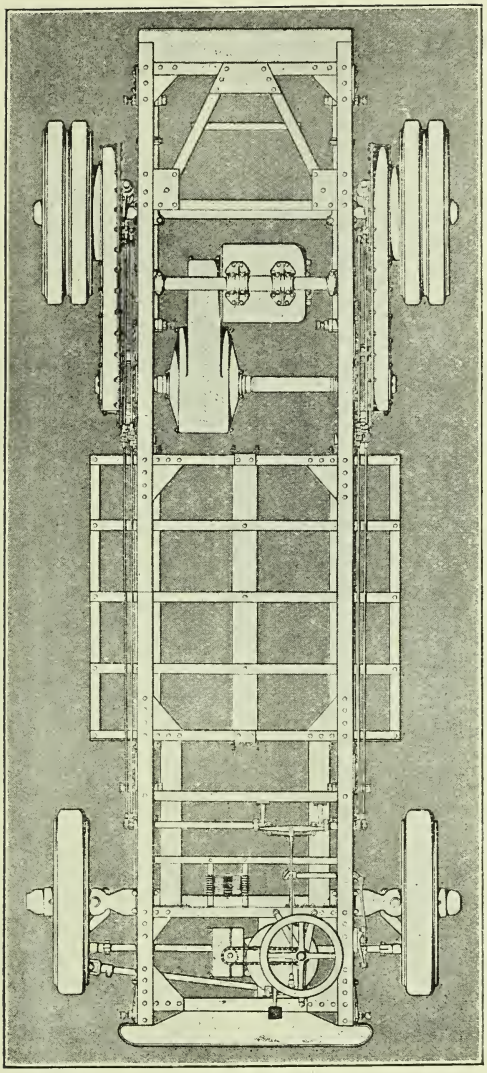


View of Arrol-Johnstone-Edison Coupé. The first All-British Edison Electric Automobile.

FIGURE 38.

ungainly and archaic in appearance. The photograph of a new Arrol-Johnson-Edison electric coupé designed in collaboration with Mr. John F. Monnot will dispel any doubts as to whether this condition need remain. Although great advances have been made in the attainment of a

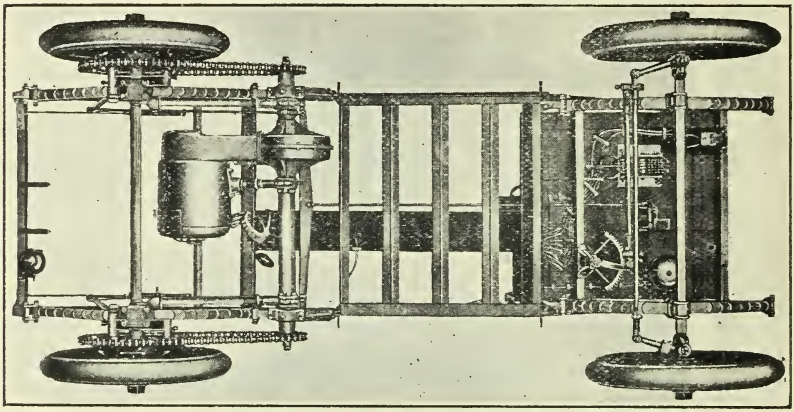
pleasing appearance in the case of pleasure cars, there yet remains something to be done on the score of proportioning the weight of the car accurately to the demands likely to be made on it. As already mentioned, anent commercial cars, there is something more than differences of opinon involved when two cars designed for the same duty differ in weight by over a ton. Being essentially a moderate speed machine it should be possible to make the electric slightly lighter than its petrol competitor for many services, particularly in the case of the heavy type of passenger machine, including 'buses, char-a-bancs and the like. This view is already borne out by the advent of the Crompton electric bus which weighs, fully equipped, appreciably less than a standard petrol 'bus of equal seating capacity. As this machine is the first of its type and therefore no doubt improvable in future models, it is obvious that great advances must have been made. The somewhat heavy design adopted by American manufacturers may probably be due to the exceedingly bad roads which are met with even in many of the more important cities of the United States. It is likely therefore that the excellent roads of the United Kingdom may permit of a considerably lighter type of machine coming into general use here—an advantage being thereby gained in mileage. As is natural, the design of American commercial electrics has followed in its main features closely on the lines laid down by the petrol car. Frames are usually of pressed steel channel form, stiffened by cross bracing and gusset plates, the lightest being built up from stock sections. A sub-frame is used to suspend the battery case and also for the motor when this is geared by silent chain to a counter-shaft. The sturdy frames usually adopted can be gauged from the views shown of a five-tonner and a one-tonner—the latter was humorously termed a " worm's eye " view ! Whilst there is some diversity of practice in both battery location—this applies more particularly to pleasure cars—and to the method of mounting the motor, there is a general unanimity of practice in choosing chain drive as the final transmission for commercial cars. Alternative ways of gearing the motor have already been referred to anent transmissions. The live axle is but rarely used on



Baker 5 ton Electric Truck Châssis.

FIGURE 39.

commercial electrics—though a tendency is observable in that direction in the latest models. The most usual position for the battery is amidships and longitudinal—thus permitting of easy access for examination when necessary. In one or two cases the battery is mounted in two trays—one on each side of the chassis—which can be pulled out sideways on castors, the side lid of the battery box serving, when hinged down, as a horizontal platform for this purpose. It it not usual to make provision for unshipping the battery in place of a "freshly charged" renewal. Practice favours rather the method of giving a vehicle a battery adequate



Underneath view of G.V. Company's Commercial 1 ton Châssis.

FIGURE 40.

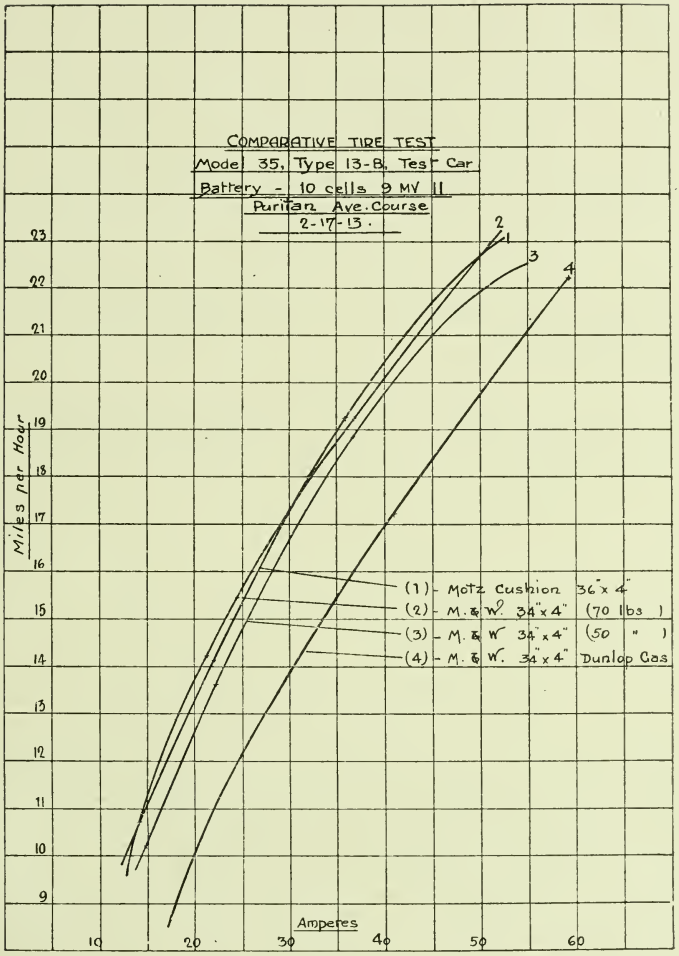
to deal with an average day's work. Springs have received much careful attention and are usually provided with well lubricated shackle bolts having stauffer grease-cups to maintain that desirable condition. American designs of steering gear would not strike the British engineer as being sufficiently robust—nor does much attention appear to be given to the possibility of taking up wear on the reduction gear thereof. Irreversible steering, especially on a heavy chassis, entails an unpleasant backlash on the steering wheel unless the steering gear be in very good adjustment. Another

feature of American design lies in the frequent practice of arranging the steering connections *in front* of the axle It is not a vital point, though where possible—and these cases are a majority—it would seem better to place the cross rod out of reach of accidental bumps. Exception might also be taken to the inadequate and inaccessible arrangements made for applying an oil can or filling grease cups on some cars. The ball-snap lubricating terminal may be cheap, but it is certainly very inconvenient, especially when situated in some place where the oil can spout can approach it only horizontally. Mud wings are another improvable detail—these do not encircle the wheels enough, nor sometimes is the front guard provided with an extension flap, the absence of which entails splashing of body work and an absence of the smart appearance associated always with the electric. The authors wish to call attention to these points merely to remind engineers that there yet remains room for improvement in the details of the commercial electric automobile, although in the main our American friends must be complimented highly for having made an exceedingly sound job of this machine.

Tyres.

The tyre problem is one that has not been studied as carefully as it warrants by engineers. Speaking generally, it is assumed that if a wheel be shod with a tyre sufficiently large in cross section to carry its load, whilst possessing also a good degree of resiliency, then, granting durability and freedom from road trouble, no other consideration need be involved. Perhaps such a view of the condition is warranted when specifying tyres for a heavy petrol machine—as the large excess of power over average requirements available, renders any loss of wheel to road efficiency unnoticeable excepting in the fact that some tyres may get unduly hot. With the electric the tyre question is a very important one, even more important in many instances than, say, the choice between chain and gear transmission. For heavy machines the chief consideration appears to be not to equip with tyres that are very soft. A medium hard tyre gives noticeably

better mileage, due partly no doubt to the lessened internal work performed on the tyre. This loss is evidently a function of the depression of the loaded tyre as compared with the same tyre unloaded. The exact relation between resiliency, speed, load, and internal loss are apparently not at present known; though differences in mileage of as much as 50 per cent. are stated to have been measured on the same vehicle by changing over from one make of tyre to another, all other conditions remaining unaltered. Pneumatic tyres afford the same type of comparison, similar to the now well-known differences existing between the so-called "cord" tyre and tyres of the canvas type. Carefully made experiments in England have proved that one make of tyre absorbs 100 units of energy, whilst another under the same conditions fritters away 180 units. It will not be surprising therefore to learn that some recent experiments on an electric car proved that the ordinary type of pneumatic tyre absorbed 25 per cent. more power from the battery than the standard make of "special electric" tyre. The curve showing these results is reproduced—the trials were made this year. Unfortunately there appears to be as yet very little information available on this interesting subject. Evidently it is worth studying however. The special tyres referred to are the light walled tyres having a moderately thin resilient tread. Such tyres would of course be useless on a high powered petrol car. For very heavy electric trucks special tyres composed of a series of wood blocks arranged close to each other around the rim have been tried—apparently with satisfying results where the roads are moderately unindented. Another experimental tyre for the same purpose was composed of a chain of short lengths of steel wire cable encircling the wheel transversely. The ends of the short pieces of cable were electrically welded, thus preventing any tendency to fray. Several designs of spring wheels that have proved unsuccessful for the high speed for which they were intended originally may prove eventually useful to the electric. Inventions sometimes progress in such a way. A few remarks on the subject of wheels are appropriate at this point. When machines are fitted with small wheels the power consumption may mount up considerably beyond


COMPARATIVE TIRE TEST
Model 35, Type 13-B, Test Car
Battery - 10 cells 9 MV 11
Puritan Ave. Course
2-17-13.
Miles per Hour
Amperes
(1) - Motz Cushion 36" x 4"
(2) - M. & W. 34" x 4" (70 lbs)
(3) - M. & W. 34" x 4" (50 ")
(4) - M. & W. 34" x 4" Dunlop Gas
Curve Sheet N° 286

Showing the relative Power Consumption on an Electric with various makes of Tyre.

FIGURE 41.

what is necessary. The size of a wheel may affect the total tractive effort in two ways: (1) By *reducing* the tractive effort per ton in a manner inversely proportional to the * square root of the diameter; and (2) by increasing or reducing the tractive effort proportionally to the added weight increment of the larger or smaller wheel. This latter effect is very small, however, in practice and may be ignored. The diametrical effect however is not so negligible, as the appended table will show. The difference in road resistance between wheels respectively of 30 inches and 40 inches is 14 per cent. —quite a useful figure on a battery car. Practical considerations including cost, must naturally limit the size of wheel permissible.

Wheel diameter.	Relative tractive effort at same road speed for all wheels.
30 inches	100
32 ,,	97
34 ,,	94
36 ,,	90
38 ,,	88
40 ,,	86

ELECTRIC VEHICLE MOTORS.

With certain exceptions the series motor is employed in automobile work almost exclusively, its high starting torque constituting a practical advantage that so far has offset the defects of momentarily heavy copper losses and consequently reduced efficiency during acceleration periods. In the past many experiments have been made with compound wound motors in an attempt to obtain greater overall efficiency together with in some cases the advantage of electrical braking regeneratively employed—that is by absorbing the kinetic energy of the decellerating vehicle, and storing it as an intermittent high rate battery charge. The best known of these systems are the Crompton—which is a pure battery

* Col. Crompton, *Proc. I.A.E.*, Vol. II., *p.* 395.

system—and the Thomas transmission, which though excellently applicable to battery conditions, was designed originally as a mechanical electrical transmission. These clever attempts at solving a most difficult problem are referred to later in this paper. Taken altogether there seems little likelihood of regenerative or what might be better described as " conservative " systems of transmission finding very wide application on the lighter types of road vehicle—such as pleasure cars and delivery vans. For public passenger carrying and the heavier type of commercial trucks however, the possibilities are much more hopeful ; in fact it would be surprising if the two systems already mentioned did not make great headway wi hin the next few years in the battery traction field. American practice in the building of electrics appears to favour the fitting of a motor of already proved reliability designed by electric motor specialists rather than following the course of experimenting with a view possibly to effecting improvements. Taken altogether there is much justification for allowing the electrical manufacturer to be arbiter of the motor question, though improvement is less likely to be rapid in the circumstances where contracts for manufacture can easily take precedence over all other points of view ! In spite of the fact that with few exceptions American makers of electrics appear to confine their choice of motors to about three makes, there is a most surprising lack of unanimity in the ratings quoted on this heading in catalogue descriptions of complete vehicles. Some makers state specifically that there is no overload capacity—others guarantee 300 per cent. overload capacity for thirty minutes, whilst others throw caution to the winds and boldly claim 800 per cent. overload capacity, and one maker evidently very cautious, is willing to permit only 25 per cent. overload. Evidently different makers have different ideas as to the method of defining overload capacity. The authors suggest that a rational method of rating vehicle motors would be to define normal rating as that b.h.p. output required on a hard level rolled dry road with vehicle fully loaded—this figure being taken as an average for say a mile journey each way, after the car had done an hour's work fully loaded on an undulating road.

The index of overload capacity should then be expressed as a percentage measure of the current value allowable for thirty minutes as compared with normal current—this overload current being not greater than occasions a temperature rise of 100° centigrade after thirty minutes continuously. The rating suggested is based on some measurements made with American machines of proved mechanical and electrical sturdiness—these qualities being the most important in practical vehicle work. There is not much to be said in favour of extra high-speed motors, nor for motors running at very low speeds—for the motor weight saved by high speed entails more weight in transmission gear and two reductions therein—whilst the very slow speed motor costs more initially and weighs too much. On an average the best practice inclines to motor speeds of 800 to 1,000 r.p.m. or thereabouts. The desirability of enclosing a vehicle motor makes the temperature difficulty greater, and it is suggested that some attempts at internal ventilation might be practicable in spite of dust troubles—which however get less every year and are not now considerable in most towns. The overload rating could thus be increased considerably. The usual construction of these machines favours a carcase of cast steel, generally of the four-pole type. Considering the extra cost of making the field carcase from laminations would be hardly more than 15 per cent. and that a reduction in weight of 25 per cent. is claimed for this method of construction, there appears to be an opening for improvement in such a direction. Whilst the weight question takes a relatively minor place in the design of heavy machines it is by no means to be ignored. For pleasure cars and all higher speed work it is manifestly necessary to cut weight down as much as is consistent with reasonable overload capacity and mechanical stability. American vehicle motors appear to weigh from eighty to one hundred and eighty lbs. per b.h.p. —the overload capacity being usually, as already mentioned, very high. The table shows the normal output and weight of a series of American vehicle motors. It will be noticed that motor 3, a small machine designed for light runabout service, shows up extremely the specific heaviness of very small low voltage and low speed machines, whilst the

characteristics of number 2, a very high speed machine, enable it, in spite of low voltage, to give the respectable output of 1 b.h.p. at normal rating for 100 lbs. weight. An important mechanical feature of vehicle motor design lies in making provision for withdrawing the armature shaft without disturbing the armature or its winding. This is accomplished

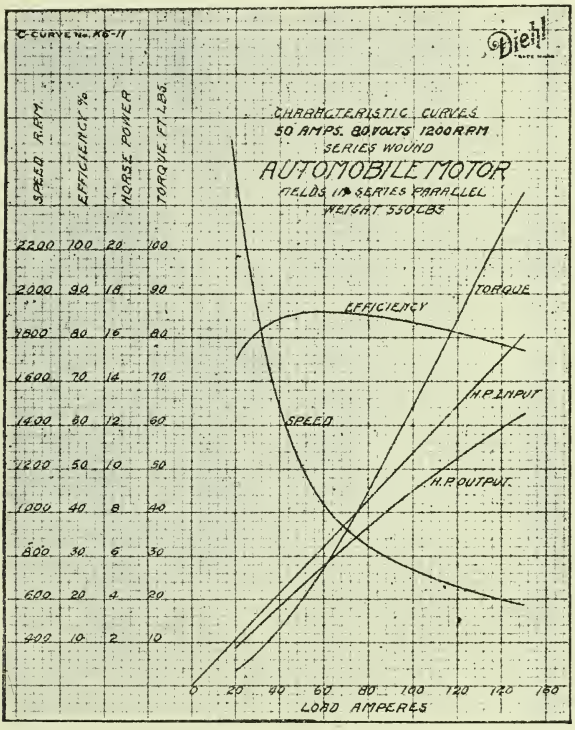


FIGURE 42.

by mounting the armature and commutator on a sleeve through which the shaft passes, enabling replacement of a worm or damaged shaft at a minimum expense of time and money. Sometimes the extension of the motor shaft is employed for the reception of a coned brake drum. It is

not considered that this is good practice, as although the braking action is undoubtedly most powerful, there is some danger of shearing off the motor shaft which must of necessity be too limited in diameter to stand such abnormal strains. Although ball bearings are often employed for motor shafts there is much to be said for a good roller bearing

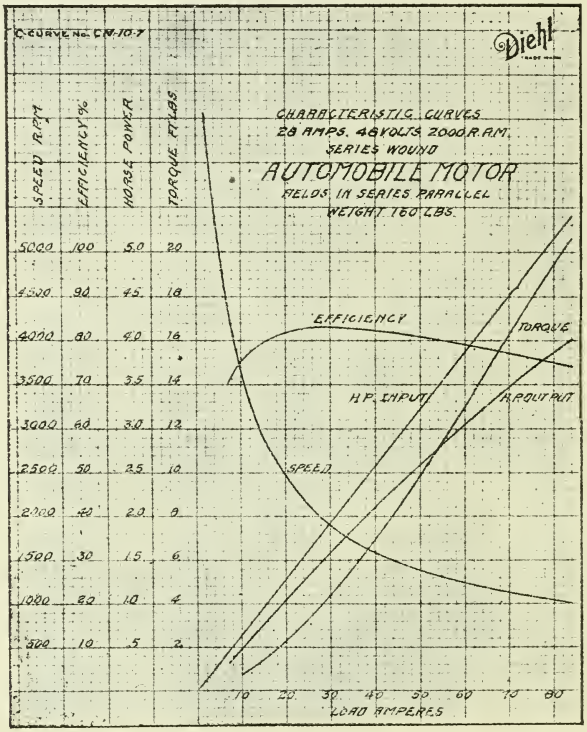
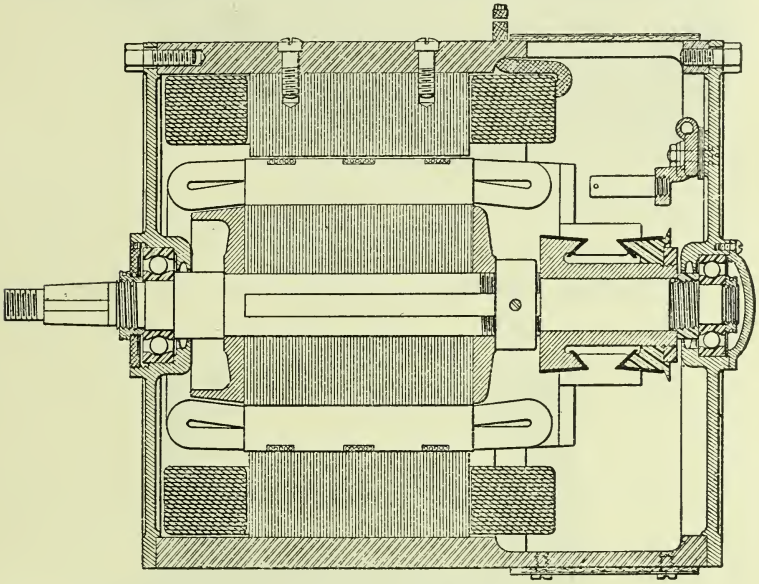


FIGURE 43.

in this location. The roller bearing requires lubricating as infrequently as the ball type, and appears to be a little more reliable. Leading-in cables of American vehicle motors are often unprovided with terminals externally. This is an improvable arrangement, and would be more effectively dealt

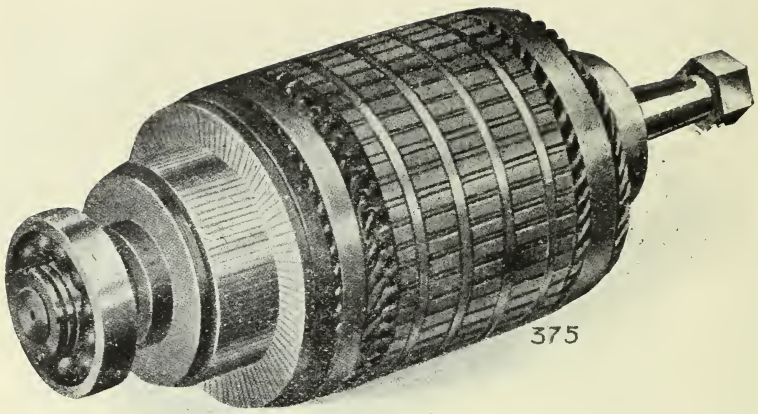
with by the provision of a robustly designed contact block made easily removable—together with the usual cables—by the loosening of a single bolt. The curves (Fig. 42 and 43) show the electrical characteristics of two electric automobile motors of good reputation. The efficiency will be observed to be well over 80 per cent. throughout the working range of the machines. Even at heavy overload currents, however,



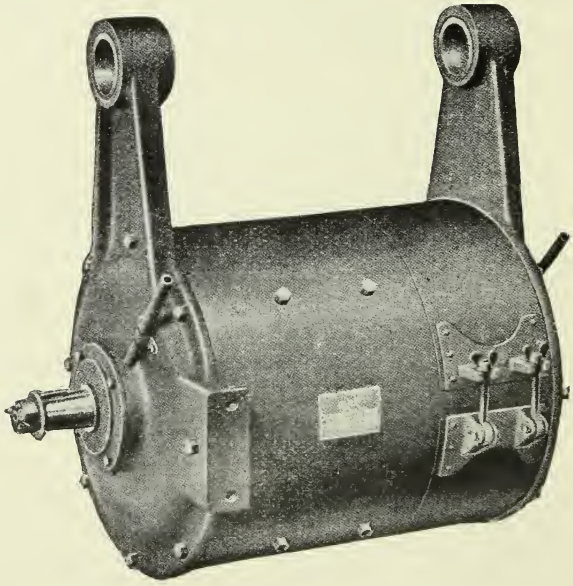
Sectional View of Diehl Automobile Motor, typical of the best American practice.

FIGURE 44

the falling off in efficiency is small, but increases rapidly, due to the heavy copper losses which are well known to accumulate as the square of the current. This last fact is the *raison d'être* of the various electrical transmissions, upon which so much time and brains have been spent. By the courtesy of the designers it has been made possible later on to describe two such systems. Referring to the characteristic curve (2) it will be seen that a motor taking 50 amperes at 80 volts can be operated over a range of from 2 h.p. to 11 h.p.

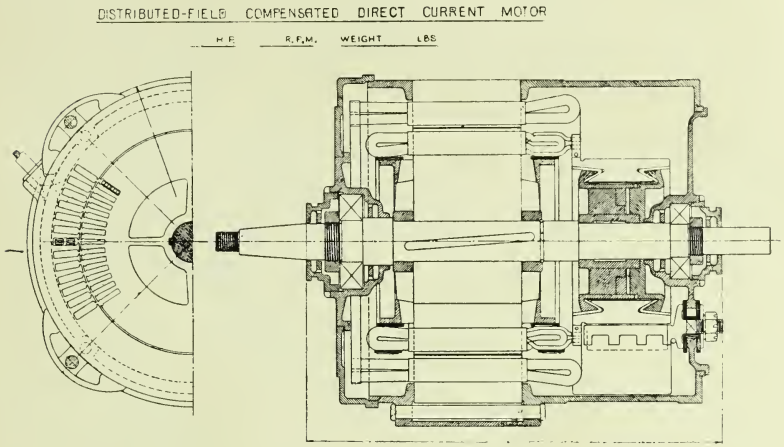


Armature of Diehl Automobile Motor, showing Ball-bearings.
FIGURE 45.



External View of Diehl Vehicle Motor showing brackets for supporting back-gear Shaft.
FIGURE 46.

without the efficiency falling off below 80 per cent. The steep torque-current curve will also be noted. The general mechanical construction of a typical vehicle motor may be seen from the line drawing. Other views show a complete motor, also an armature and shaft with ball bearings as employed generally.

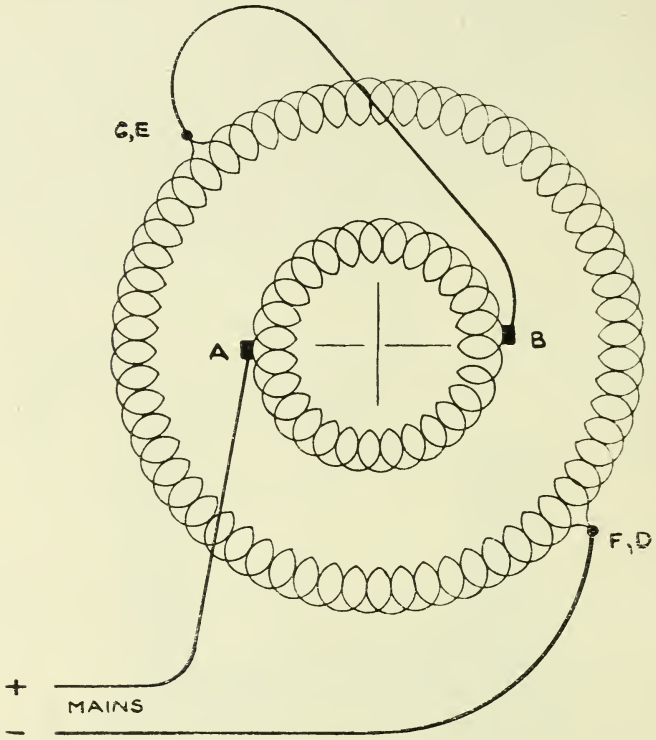


"J.L." Motor designed specially for high efficiency and very low weight.

FIGURE 47.

Mention should be made here of an exceedingly interesting design of motor made at the J.L. Works, possessing features which should make it eminently suited to automobile conditions. In this machine a radical departure in design is made as compared with ordinary practice. In place of the "solid" salient poles the field frame is built up from laminated multi polar stampings somewhat like an armature turned "inside out." The field windings employed are of strip form and are connected in a continuous series forming a closed circuit like an armature winding. The drawing

shows the actual arrangement employed, and a diagrammatic sketch indicates the connections which are used for a series motor. Very perfect armature compensation together with

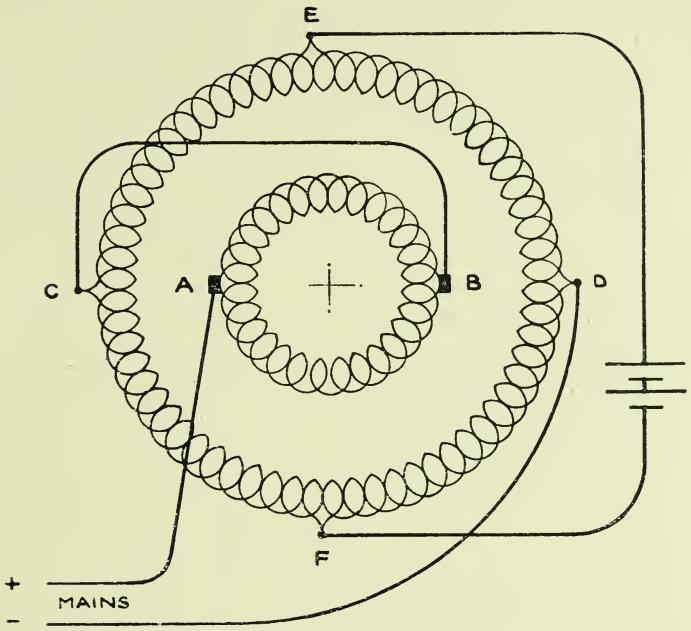


Diagrammatic representation of windings of "J.L." Distributed-Field Series Motor.

FIGURE 48.

all the qualities of a commutating pole motor are gained by this arrangement. It will be seen from a study of the field windings that it is possible to effect the three distinct

functions of : (1) Providing working flux for the armature ; (2) compensating totally for armature reaction ; (3) introducing



Diagrammatic representation of windings of " J.L." Distributed-Field Shunt Motor.

FIGURE 49.

a commutating flux into the armature. The special features claimed with this type of winding are :—

(1) Light weight and small dimensions for a given power output.

(2) Wide speed variation with brushes in fixed neutral position, thereby making available for either direction of rotation.

(3) High overload capacity with sparkless commutation.

(4) Rapid acceleration due to the low inductance of field winding.

A saving in weight of 30 per cent. is stated to be possible for any given rating as compared with the results attained using average construction. There should be a considerable future for this motor, if practical tests under automobile conditions justify the results already attained on the test-bed.

TABLE OF IMPORTANT CHARACTERISTICS OF ELECTRIC VEHICLE MOTORS.

Number.	Speed. R.P.M.	Volts.	Amps..	B.H.P. at 80% eff.	Weig't	Weight per B.H.P.	B.H.P. per 100 lbs.
1	1,700	20	27	0·57	90	156	0·64
2	2,250	28	33	0·93	90	98	1·02
3	740	40	28	1·20	205	171	0·51
4	1,600	40	28	1·20	165	129	0·63
5	1,000	36	35	1·34	155	116	0·86
6	740	80	16	1·36	190	140	0·56
7	1,600	80	16	1·36	160	118	0·67
8	1,500	60	23	1·47	155	105	0·95
9	950	60	30	1·92	250	130	0·77
10	800	110	16·5	1·94	155	80	1·25
11	1,200	60	31	1·98	270	136	0·77
12	1,200	85	22	2·00	250	125	0·80
13	900	80	24	2·03	235	115	0·87
14	1,200	80	25	2·13	250	117	0·86
15	1,800	72	28	2·15	196	92	0·09
16	850	80	27	2·31	254	110	0·91
17	900	80	28	2·38	270	113	0·88
18	1,400	60	40	2·56	270	105	0·95
19	850	80	31	2·64	282	106	0·94
20	700	56	45	2·69	520	193	0·52
21	1,100	60	45	2·88	350	121	0·82
22	900	60	85	5·44	550	101	0·99

ELECTRICAL TRANSMISSION SYSTEMS.

Reference has been made to so-called "conservative" systems of applying battery energy to road wheels. Of the many experiments made in this field two are selected for description which have reached the practical stage and appear to have a wide field of usefulness before them. Both these systems, the Crompton and the Thomas, are the product of British brains and capital, and in their respective spheres have already proved their engineering validity.

The Crompton Electric Valve.

The basic principle underlying this system of using a storage battery to propel an automobile involves the employment of an electrical means of limiting the maximum rate of discharge of the battery to some predetermined allowable rate. Thus a three-fold effect is obtained. Firstly, the life of the battery is greatly increased, resulting in lower upkeep charges and more uniform reliability; secondly, the battery when run in this manner will give its maximum output of work; and thirdly a reduction in weight can be gained for any required service conditions as compared with the weight of a " straight battery " equipment. The so-called " electric valve " is in reality a special type of motor dynamo working in electrical association with a compound wound motor, the field of which is designed to strengthen up as the motor speed falls. The torque-speed characteristics of this machine is of the same form as that of a series motor ; hence, a heavy current at low voltage can be used to maximum advantage at starting ; a feature essential for rapid acceleration, and which makes regenerative speed control of the car a successful possibility. The diagrammatic representation of this system will be understood on reading the following description for information bearing on which the authors are indebted to Mr. Burge, one of the designers of the Crompton transmission. Referring to the diagram the machine 1, 2 has really a double function—one (1) being that of a motor across the battery terminals the other (2) a dynamo connected in series with the motor (3) which can thus receive a maximum voltage equal to the dynamo voltage, plus the battery voltage. In this design the limit of maximum voltage across motor (3) is twice the battery voltage. The motor part of 1, 2 is excited at constant potential by a shunt coil across the battery terminals. The excitation of the dynamo part of 1, 2 is provided for by coil 8 which is in series with a reversible regulator 5 and the battery, so that it is thus possible to vary the excitation due to this coil between wide limits. Thus with the battery voltage opposing dynamo voltage, the field would be full negative whilst when the battery and dynamo

voltages are added the field would be full positive. The controller arm will therefore on one side cause the dynamo voltage to be added, and on the other

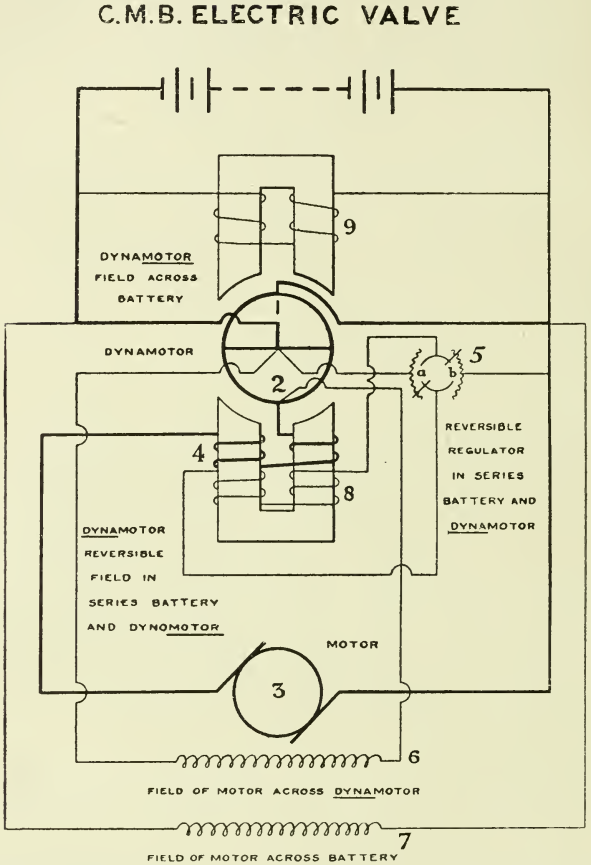


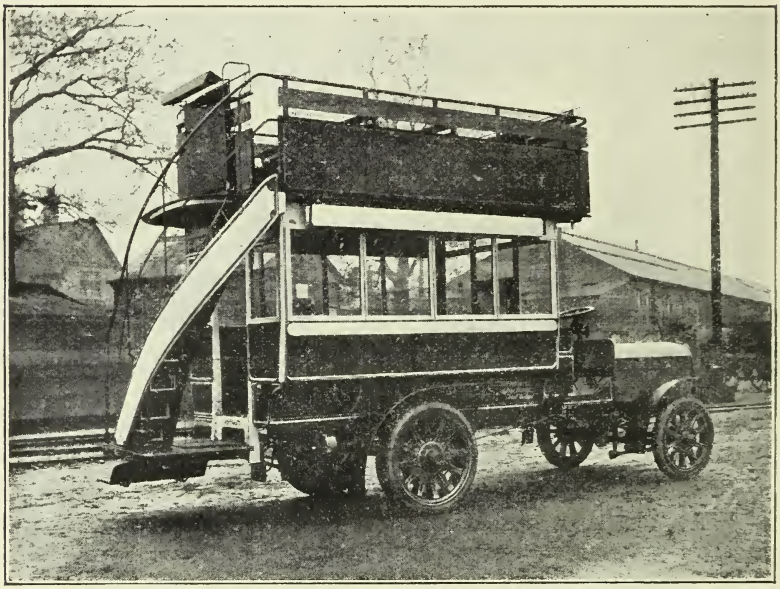
Diagram showing principle of Connections in the Burge-Macfarlane Transformer System as applied to the Crompton Electric Bus.

FIGURE 50.

side subtracted from the voltage due to the battery. The dynamo is also provided with a coil 4 in series, with the motor 3, and opposing coil 8 when motor 3 is taking

power from the dynamo. The excitation of the motor 3 is effected by two shunt coils, one 7, being across the battery, whilst the other 6, is across the dynamo 2. These coils are so arranged that during starting and subsequent acceleration the field of motor 3 is due almost entirely to coil 7. As speed increases the field due to coil 6 increases, and thus opposes winding 7, the field finally attaining a value which is the difference between the stronger field induced by coil 7 and that induced by 6. Thus when decelerating due to increase of load on motor 3, the field of the dynamo will be weakened, due to the increase of current in series coils 4. This will cause an automatic limitation of the current possible to be taken from the dynamo, since, at the same time, the voltage across coil 6 will be reduced, thus strengthening the motor 3 field due to the difference between the excitation due to windings 7 and 6 becoming greater. But with a stronger field the torque of motor 3, increases, whilst speed tends to decrease, due to the fall in voltage across the dynamo occasioned by a heavier current in winding 4. This condition is what is required. The motor 3 is designed to deliver a torque nearly proportional to the square of the current, thus a quick start can be made from standstill involving a current only 2·5 times normal current for level running. The *C R* cosses are therefore low and a high overall efficiency attained. An average acceleration of 4·5 feet per second per second is obtainable under normal level running conditions. The operation of the system will be clearer if a sequence of operations be followed in detail as they would occur on the road. When the vehicle—in this case a thirty-four passenger 'bus is at rest—the reversible controller will be in the position *a*, *b*, so that there is full negative excitation of machine 2. Current having been turned on to machine 1, the controller is now turned towards the side corresponding to full positive field on machine 2, say to the left. Assuming the torque on the motor to be sufficient to move the 'bus and that the controller handle be not touched, the current flowing in coil 4 will reduce the field of 2, hence its voltage will fall and the strength of the motor 3 field will increase, thus tending so slow up the motor. Meanwhile, however, the 'bus is accelerating, and will continue to do so until uniform speed

is attained. A further movement of the controller handle increases the field due to winding 8, thus allowing more current to flow through the motor 3, and weakening its field because of the increased current through the winding 6. Finally the motor is rotating at maximum speed for the particular conditions. The action of braking the 'bus is achieved by reversing gently the handle of controller 5. This has the effect of reducing the voltage of the dynamo to a



Omnibus equipped with Crompton System of Transmission.

FIGURE 51.

point lower than the back E.M.F. of the motor 3. Hence current flows back into the battery. The amount of this regenerative charging current is regulated automatically by the field coil 4, which increases the value of the back E.M.F. of the machine 2, thus preventing the possibility of doing damage to the machines. Obviously the control of the

Crompton 'bus is ideally simple, and in fact the majority of the driver's work is simply to press a single pedal, which controls speed and braking as already noted. It would be possible to drive without using a mechanical brake—and in fact recourse to a brake other than electrical is found to be necessary only in an emergency. By proportioning the resistance of 5 suitably a small negative current of very small power is caused to circulate in the driving motor 3, giving the armature a slight torque in the reverse direction. This useful property enables the Crompton 'bus to stand on a hill with a " backwards " declinity of 1 in 28. Experiments made recently in London streets under similar conditions to those existent in practice showed that over a city route of eleven miles 17 per cent. of the battery energy withdrawn was returned to the cells due to the regenerative action of braking—mainly on account of the numerous traffic stoppages. Very low consumption of current per ton mile has been recorded with the Crompton system of transmission, The photograph shows the completed bus—and a line drawing indicates the general arrangement as originally adopted.

The Thomas Transmission.

Although so far this arrangement of power transmission has not been applied to any purely battery propelled automobile, it is, in the author's opinion, so eminently likely to be successful in the heavy vehicle field for city work, that a description is warranted. Broadly stated, the objects of the Thomas device are similar to that of the Crompton—namely, the conservation of motor energy (*i.e.*, battery output) during periods of acceleration or when hill climbing. Doubtless many of the engineers present know that the correctness of the Thomas principle has been thoroughly established already, including the winning of the Dewer trophy—in connection with an R.A.C. test in 1911, when a 12 h.p. car gave a ton mileage of 67·9 per gallon of fuel used—and a further record performance of 228 ton miles per gallon on a rail car in use on the Central South African Railways. This latter result is accredited

by the Government engineers of the Central South African Railways, and certainly will not be equalled or excelled without difficulty. Up to the present various types of locomotive, road and otherwise, ranging from 12 h.p. to 200 h.p. have been equipped—in every case satisfactorily it is stated. One would naturally deduce that if such satisfactory performances can be gained with the T.T. in conjunction with heavy internal combustion vehicles, the results should be at least equal and possibly better—when pure battery propelled vehicles are in question.

Neglecting for the moment the question of first cost—the advantages to be gained by running the Thomas Transmission in conjunction with an electric automobile appear to be :—

(1) An increase in mileage for a given weight of battery, especially where there are frequent stoppages and much hill climbing.

(2) In the case of the lead battery, prolongation of battery-life, due to the reduced current required for acceleration and hill climbing.

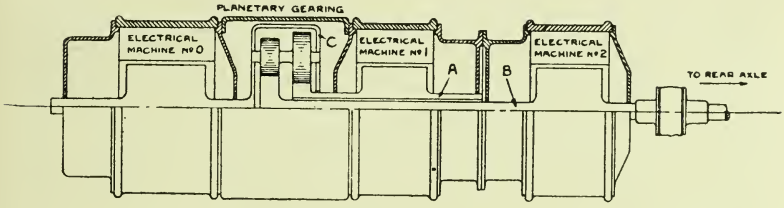
(3) Quicker acceleration than can be obtained with the " straight electric " drive.

(4) Higher speeds up-hill.

(5) Greatly increased efficiency because of the facts that 1, the prime motor need never take more than normal current ; 2, there are no rheostatic losses ; 3, regeneration is simply effected.

Whilst speed control is, if anything, simpler than with a straight electric drive the only remaining objection, that of possible noise in the epicyclic casing, can be put aside as negligible, experience in other applications of such gears have proved their complete silence. This naturally leads to a description of the Thomas system. Originally this device was evolved with the idea of making available an infinitely variable speed torque gear change. Any type of

prime mover is employable with the gear, and drives a planetary casing carrying sun and planet gears as shown in Fig. 52. Essentially the planetary gearing is the equivalent of a differential gear of three members—the casing *C*, driven directly by the prime mover, the auxiliary shaft *A*, which is driven by the small sun wheel, and the load shaft *B*, driven by the large sun wheel. The shafts *A* and *B* carry respectively the armatures of electric motors numbered "M/C 1" and "M/C 2". The motive of the mechanism is the provision of an efficient means of varying the speed and torque of the shaft *B* at will. This shaft drives the vehicle, the speed of the prime motor *O* being maintained at its most efficient value. The speed relations of the three members of the



- THOMAS TRANSMISSION FOR PURE ELECTRIC TRACTION

FIGURE 52

gearing are indicated on the speed diagram shown in Fig. 53 When the car is stationary and the prime motor is running at constant speed the shaft *A* will run at the same speed as the prime motor, but in the opposite direction. As the speed of the car increases and therefore that of the shaft *B* in the forward direction, the speed of *A* decreases in the backward direction becoming eventually almost zero—the cause of these variations being a progressive adjustment in the fields of the two machines, M/C 1 having its field strengthened, whilst that of M/C 2 is weakened. Up to this stage the shaft *B* has been subjected to two torques—(*a*) a torque due to the geared up mechanical reaction of the prime motor shaft through the large sun wheel, and therefore the shaft *B*, and (*b*) and electrical torque produced by machine number 2,

acting as a motor fed by energy from machine number 1, acting as a dynamo. When machine number (1) has come nearly to rest, due to its being short circuited, the electrical torque, due to machine 2 acting on *B*, becomes of zero value. To further increase the speed of shaft *B*, machine 2 is now made a generator feeding machine 1, thus rotating it in a for-

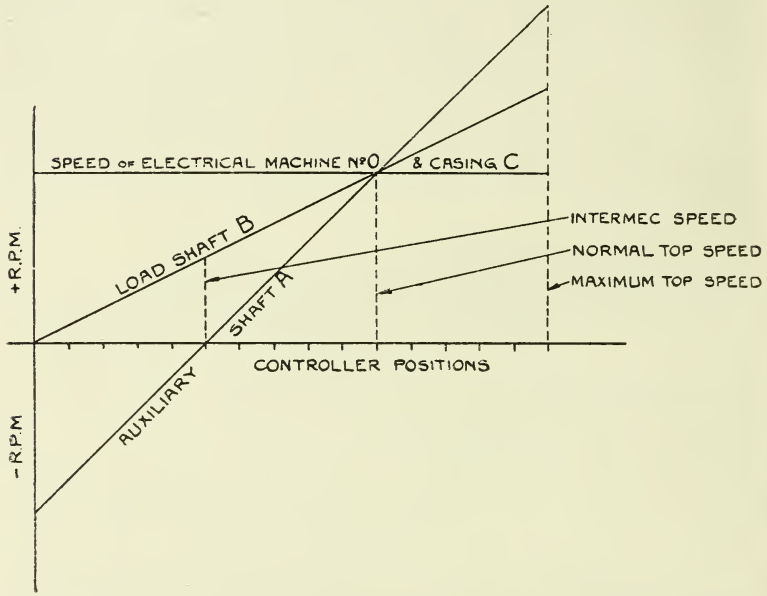


FIG. 2 - THOMAS TRANSMISSION SPEED DIAGRAM

FOR SYSTEM WITH PLANETARY GEAR RATIO = 2:1

FIGURE 53.

ward direction until the voltage across its terminals equals the battery voltage. At this point machine number 2, is cut out of circuit and machine number 1 is supplied directly with current from the battery. When the speed of machine 1 has risen to that of the prime motor there is no relative motion in the planetary gearing, the casing and pinions

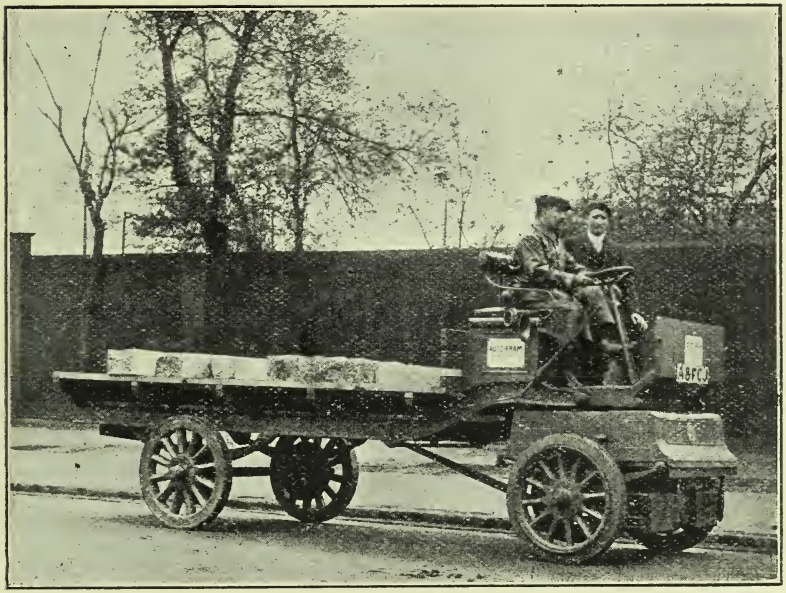
therefore revolving solidly. If desired a further increase of speed can be attained by weakening the fields of machine 1, thus causing it to " overtake " the prime motor and effect an increased speed on the driving shaft *B*. This is shown on the speed diagram in Fig. 2, as maximum top speed. The speed referred to as the " intermediate mechanical " is thus described to signify that under these conditions the transmission is purely mechanical from machine *O* which is acting as prime motor. For automobile purposes machine *O* would be a shunt motor excited from the battery and running at practically constant speed. It would have reversible field connections and be provided with field regulation to make possible a fair degree of speed variation. The shunt motor would be started up light, regulation and control of the speed of the car being effected by the Thomas Transmission only. Although to judge from a description this system might appear involved it is nevertheless true that few such devices could hope to be made so simply. All the changes enumerated can be made in a few seconds and controlled by one lever. It might also be thought that the apparatus would entail considerable increase in cost and weight. If, however, it be remembered that the prime motor can run always at high speed it will be grasped readily that the power delivered by it can be kept high also, in spite of the fact that the car may be running at a low speed as, for example, up a steep grade. Even under such conditions it is unnecessary to take more than normal current from the battery, all increase in torque required to overcome the grade resistance being provided by the torque multiplying effect of the transmission. Thus it will be seen that the efficiency at low speeds of the car is very much greater than is possible with the straight electric drive, where large currents must necessarily be taken to provide large starting and climbing torques, a course involving, unavoidably, very large losses owing to the motor losses increasing so rapidly—as the square of the current in fact. Owing to the fact that machine *O* always develops its power at high speed, and because for the major portion of the running time it operates in parallel with No. 1 machine, the two together forming one prime motor, it can obviously be made very much

smaller than the single and less efficient mtoor that would be used for the straight electric drive. The authors are assured that the power ratings of machines *O*, 1 and 2 would in general be approximately 60 per cent., 40 per cent., and 40 per cent., respectively, as compared with that of the single motor called for by the direct system. The three motors would be assembled in a barrel form as shown in Fig. 52, the separate sections being spigoted into one another, and so arranged that there would be no possibility of the running members getting out of alignment. The total addition to the weight of the mechanical equipment would be approximately equal to the weight of a single motor required in the direct case, and the extra cost approximately equal to the cost of such a motor. The extra weight of the equipment is stated to be balanced by the saving possible in battery weight. Hence, the determining factor as to whether the system would be applicable is cost—not necessarily first cost, but rather total cost per ton mile reckoned over a fairly long period. In the case of a half ton vehicle, the extra first cost is said to be about £40. The Thomas Transmission should find its widest field of utility on heavy machines operaing on routes where slowing down, stopping and restarting occurs often—a saving from 12 per cent. to 15 per cent. in battery energy being saved, together with much decreased maintenance for the battery when this is of the lead type, due to the far more uniform conditions of service. Doubtless the future will bring forward other systems of electrical transmission for automobile service. The sooner this occurs, the better it will be for a much too undeveloped branch of engineering. The authors had hoped to have described one of these newcomers—a system known as the Autolectric, which is said to promise well. All this proves that we are on the verge of an awakening.

THE F.R.A.M. FRONT DRIVEN ELECTRIC TRACTOR.

Though not strictly speaking involving any new system of transmission the F.R.A.M. machine is deserving of some special mention on account of the ingenuity displayed in its design. As can be seen from the photograph of a 3½ tonner

the whole of the mechanism is mounted on a truck which is pivoted vertically so that the two wheels may turn nearly at right angles to their normal direction. Steering is effected entirely by electrical means—namely, by accelerating one motor above the speed of the other, thus causing the whole vehicle to turn towards the faster wheel. Braking is by regenerative control, the two motors, which are each geared



F.R.A.M. Front-Driven Machine to carry 3½ tons

FIGURE 54.

to one wheel, then functioning as dynamos. There is also a mechanical brake, which can be operated on the rear wheels of the trailer, and may be of the simple block-rim type. The special utility of the F.R.A.M. machine will doubtless be for municipal work, its adaptability to almost any service making it an economical unit. For example, the same tractor can in a few minutes be transformed into a dust-cart, water cart,

road sweeper or general service waggon—this being achieved by disconnecting the rear part from the front and substituting an appropriate trailer portion. The F.R.A.M. is exceedingly handy in point of the ease with which it can be manœuvred in awkward turns, it being possible to turn the machine almost in its own length. The normal battery equipment is a lead type 80 V, forty cell accumulator weighing about eighteen hundredweight and giving an output of 240 A.H. On some recent tests in London a distance of thirty-one miles was accomplished on one charge—the test including stopping hundreds of times and restarting. Current consumption appears moderate on this machine, being about 1 unit output per mile. These machines are used considerably in Paris for municipal purposes. The front driven utility electric should have a healthy future before it.

THE PLEASURE AUTOMOBILE.

Throughout this paper attention has been confined mainly to the commercial machine—not because the passenger electric is unimportant, indeed the very contrary is true, but because the future of the industry and the greatest results hanging on that future appear to be invested in the commercial machine. To the majority of owners of private automobiles the fascination of sheer mileage, coupled with speeds that are often dangerous, outweigh most other considerations. Another and smaller class exists however, which would welcome the reliable, noiseless, clean stateliness of the electric automobile. This class is well worth while looking after, and will prove itself to contain a large enough number of professional men, ladies, and erstwhile, owners of horses—who have never yet taken to the petrol machine—to keep quite a few high grade pleasure-electric concerns busy right from the beginning of their activities. It is not now intended to discuss the engineering side of the pleasure electric, as the remarks made already apply in essence to the design of these machines. The American passenger

electric has had a long start—about fifteen years now since the first machines were made—and consequently the modern product involves fewer improvable features than is the case with the commercial machine. For example, on the weight question there is apparently not any criticism to be made, many of the chassis being remarkably strong and light, whilst the coach work, though not so highly finished as European ideals would dictate, yet shows much thoughtful care both in its seating arrangements, general comfort, and external appearance. Some of the American pleasure cars may justly be called beautiful, and when beautiful appearance is combined with silence, mechanical ruggedness, very clever advertising, together with catalogues that are works of art, there is no wonder that at the time of writing the passenger electric is easily in a majority in a country where, as is well known, "feminine persuasion" is the power behind the purse! The passenger electric has been developed to its present degree of elegance mainly because a woman so greatly appreciates finely-done coach trimming and luxurious interior fittings, and therefore to supply this known want offered a new field of activity both profitable and expanding. The next step was natural—that many women should learn to drive their own car; hence in most American cities the woman owner-driver of an electric is very common. The reasonable speed, absence of clutch and gears—combined with sensitive yet simple steering make these practical cars the acme of safety for feminine drivers. There is no doubt that many ladies will take up electrics in Great Britain when the advantages have been disseminated by adequate methods of publicity. Meanwhile it is interesting to note that arrangements have been made for the manufacture of twelve hundred pleasure car electrics—all propelled by the Edison battery—in the Works of Messrs. Arrol-Johnstone at Paisley. The first car is already undergoing its road trials and will doubtless have made some interesting performances to be recorded ere this paper be published. These cars are designed on the basis of information derived after extensive road tests conducted during the past year. The chassis includes many detail refinements which experience has pointed the way towards—and may fully be expected to rank among the

most interesting automobiles produced in Europe for the year 1913. The pleasure electric constitutes the cheapest method of quick transport that we have at our disposal. For example, one of the cars already mentioned will average a sixty mile journey on an energy consumption of twenty-four units battery input, equal to 0·4 unit per car mile for a four passenger car. In the face of such a figure there is a strong temptation to improve on the advertising query of one famous firm—who asked: "Why pay eight-pence a mile for a taxi when a Rolls-Royce will take you for nine-pence" by asking: "Why ever ride in a petrol automobile for city work when an electric will carry you four times as comfortably for less than half the expense?" The future will doubtless decide the problem! In the opinion of the authors there is a very wide field indeed for the pleasure electric, on account of: (1) Great reliability; (2) perfect simplicity, silence, and absence of odours; (3) absence of "stand-by" losses; (4) unrivalled comfort and cheapness of operation.

RUNNING COSTS.

It is of course not true that an electric will save money if run merely as a substitute for a fully employed existing horse-service. By this statement is meant that if on a one-horse route averaging fifteen miles per day, an electric were substituted for the one-horse van, then conditions would be inferior, as cost per ton mile must have gone up. Therefore when inaugurating an electric system of transport it must be remembered that the power machine must be working at a reasonably good load factor so as to distribute the *inevitably* higher charges per *vehicle* day. The obvious way to achieve this is: (1) either to do more work *i.e.* expand the operations of the business; or (2) use less vehicles over a greater mileage per day. Much misconception and useless argument is likely to arise unless this fundamental aspect of running cost be kept always in mind—for example—It would not pay a small greengrocer to run an electric even if the machine

were given to him, leaving him only to pay for current, tyres, &c. It is exceedingly difficult, if not impossible, to deal adequately with the question of running costs of electrics in a paper of this type where so much else has to be touched upon. It has however been proved conclusively by a most minute and extended series of observations undertaken by the Massachusetts Institute of Technology that under American conditions the electric is from 15 per cent. to 25 per cent. cheaper to run than the petrol truck—this in spite of the fact that American users pay eightpence per gallon for fuel against our one shilling and ninepence—and that in the U.S.A. electricity is hardly ever supplied at less than twopence per unit, whilst it often costs threepence. Contrast these conditions with those existent in England to-day—say London in particular. The two curves show that whilst fuel has gone up in price 75 per cent. in two years, electricity has been slowly descending for many years past. The authors are indebted to Mr. Hughman of the *Electrical Times*, for data enabling the current curve to be shown. It speaks so loudly that explanation is unnecessary. The appended tables are taken from information contained in the reports of the Electric Vehicle Association of America and show that the electric is just as definitely economical on light delivery work as it is when dealing with bulk loads.

Load rating.	Delivery service.	Miles per day.			Comp. Exs. per del. as compared with horse.		
		El.	Petrol.	Horse.*	El.	Petrol.	Horse.
					%	%	%
1,000 lb.	Suburban parcel	37	39	29	79	88	100
1,000 ,,	City delivery	33	34	24	93	111	100
4,000 ,,	Furniture	32	33	25	89	108	100
7,000 ,,	Beer	31	33	22	80	95	100
10,000 ,,	Coal	28	32	19	76	86	100

* To cover these distances by horse waggon extra horses are required.

A further table showing the cost of operating thirty trucks over a period of three years is most instructive and

cannot be refused acceptance on the score of inadequate extensiveness—a distance of a third of a million miles being involved. An additional series of dissected tables shows the cost of operating a series of trucks owned by the Chicago Commonwealth Edison Company running on lead batteries. When reviewing the various items in those tables it must be remembered that the items of wages, power and tyres would all be considerably greater than in Great Britain. For example, £75 a year will cover the wages of a delivery van driver—being in fact more than most of these men are paid. Energy also is obtainable in some London stations at 0·5d. per unit during off-peak hours. Battery charges can and will be reduced very much when greater experience has proved that higher first cost may mean much lower cost per mile in the end. A table is appended showing at what cost a 5-ton Edison Truck can be operated under English conditions.

The authors would like to have lingered over this section of the paper and gone into details far more thoroughly. It is hoped, however, that sufficient evidence has been adduced to prove what an immense future lies before the electric automobile in this country. Mr. W. P. Kennedy, an authority on electric vehicle publicity, made a stirring appeal to manufacturers and others whose interests were involved. It is felt that nothing could sum up the attitude necessary to be taken better than Mr. Kennedy's final sentence, which is quoted hereunder.

"Scepticism, prejudices or apathy from the very subtleties of their nature have been the most difficult to overcome, and it remains for the concentration of our collective mentality, greater now than ever before available, to unite in one grand galaxy of effort to execute with determination a program which will be as irresistible as it may be comprehensive."

AMERICAN COST OF OPERATION OF 700 LB. WAGGON.

(Mileage per annum 10,620 (300 days per year).

	Per year.	Per day.	Per mile.
FIXED CHARGES.	£	d.	d.
Depreciation	31	25·8	0·7
Interest	9·3	7·8	·22
Fire Insurance	3·1	2·5	·07
Third Part Risk	20	17·1	·47
Total	63·4	53·2	1·46
RENEWAL CHARGES.			
Batteries	34·0	28·0	0·8
Tyres	25·8	21·5	0·61
Chains	3·0	2·6	0·075
Gears and Sprockets	8·6	7·25	0·2
Bearings	4·4	3·66	0·1
All other parts	5·0	4·16	0·12
	80·8	67·17	1·9
GARAGE CHARGES.			
Electric power	22·2	15·5	0·525
Rent, Light and Heat	14·9	12·4	0·35
Garage Labour	46·4	38·6	1·09
	83·5	69·5	1·96
Driver	150·0	125·0	3·5
Grand Total	377·7	314·9	8·82

1,000 LBS. WAGGON.

Miles per year, 10,140 (300 days).

	Per year.	Per day.	Per mile.
Fixed Charges.	£	d.	d.
Depreciation	44·0	37·0	1·05
Interest	12·12	11·0	0·32
Fire Insurance	4·4	3·7	0·105
Third Part Risk	20·0	17·0	0·48
	80·52	68·7	1·95
Renewal Charges.			
Batteries	37·4	31·16	0·89
Tyres	29·0	24·27	0·69
Chains	5·0	4·2	0·12
Gears and Sprockets	9·2	7·67	0·22
Bearings	4·4	3·77	0·11
All other parts	6·0	5·0	0·15
	91·0	76·07	2·18
Garage Charges.			
Electric Power	24·4	20·39	0·58
Rent, Light and Heat	17·6	14·67	0·42
Garage Labour	46·4	38·67	1·105
	91·4	73·73	2·105
Driver	150·0	125·0	3·58
Grand Total	412·92	343·5	9·815

COST OF OPERATION OF 2,000 LB. WAGGON.

Miles per year, 10,140 (300 days).

	Per year.	Per day.	Per mile.
FIXED CHARGES.	£	d.	d.
Depreciation	53·0	44·0	1·3
Interest	15·8	13·17	0·39
Fire Insurance	5·2	4·4	0·13
Third Party Risk	20·0	16·66	0·49
Total	94·0	78·23	2·31
RENEWAL CHARGES.			
Batteries (Lead)	44·2	36·8	1·09
Tyres	43·2	36·0	1·07
Chains	6·4	5·35	0·16
Gears and Sprockets	10·8	9·0	0·22
Bearings	5·0	4·25	0·13
All other parts	7·0	5·8	0·17
	116·6	97·2	2·84
GARAGE CHARGES.			
Electric power	30·4	25·35	0·75
Rent, Light, and Heat	21·8	18·17	0·54
Garage Labour	46·4	38·66	1·14
	98·6	82·18	2·43
Driver	150·0	125·0	3·69
Grand Total	458·12	382·61	11·27

4,000 LB. TRUCK.

Miles per year, 9,390 (300 days).

	Per year.	Per day.	Per mile.
Fixed Charges.	£	d.	d.
Depreciation	68·0	55·6	1·8
Interest	20·4	17·0	0·55
Fire Insurance	6·8	5·66	0·18
Third Party Risk	20·0	16·66	0·53
	115·2	94·92	3·06
Renewal Charges.			
Batteries (Lead)	57·8	48·16	1·54
Tyres	57·2	47·76	1·52
Chains	7·6	6·3	0·2]
Gears and Sprockets	11·8	9·8	3·10
Bearings	6·06	5·05	0·16
All other parts	8·00	6·66	0·21
	148·46	123·63	3·94
Garage Charges.			
Electric power	43·6	36·46	1·16
Rent, Light, and Heat	27·2	22·68	0·725
Garage Labour	46·4	38·66	1·23
	117·2	97·8	3·115
Driver	150·0	125·0	3·99
Grand Total	529·78	441·35	14·105

7,000 LB. TRUCK.

Miles per year, 8,310 (300 days).

	Per year.	Per day.	Per mile.
FIXED CHARGES.	£	d.	d.
Depreciation	80·0	66·66	2·41
Interest	24·0	20·0	0·72
Fire Insurance	8·0	6·66	0·24
Third Party Risk	20·0	16·66	0·60
	132·0	109·98	3·97
RENEWAL CHARGES.			
Batteries (Lead)	71·4	59·5	2·1
Tyres	88·6	73·9	2·66
Chains	11·6	9·68	0·35
Gears and Sprockets	15·8	13·23	0·48
Bearings	8·6	7·19	2·06
All other parts	9·0	7·5	0·27
	205·0	181·00	6·12
GARAGE CHARGES.			
Electric Power	57·0	47·57	1·72
Rent, Light, and Heat	29·4	24·62	0·84
Garage Labour	46·4	38·66	1·39
	132·8	110·85	3·95
Driver	150·0	125·00	4·52
Grand Totals	619·8	526·83	18·56

10,000 LB. TRUCK.

Miles per year, 7,200 (300 days).

	Per year.	Per day.	Per mile.
FIXED CHARGES.	£	d.	d.
Depreciation	90·0	75·0	3·125
Interest	27·0	22·5	0·94
Fire Insurance	9·0	7·5	0·31
Third Party Risk	20·0	16·66	0·69
	146·0	121·66	5·06
RENEWAL CHARGES.			
Batteries (Lead)	85·0	70·83	2·45
Tyres	123·6	103·13	4·29
Chains	11·6	9·68	0·405
Gears and Sprockets	15·8	13·23	0·55
Bearings	8·6	7·19	0·30
All other parts	10·0	8·33	0·35
	254·6	212·39	8·34
Electric Power	66·0	55·08	2·29
Rent, Light and Heat	32·8	27·34	1·14
Garage Labour	46·4	38·66	1·61
	145·2	121·08	5·04
Driver	150·0	125·00	5·21
Grand Total	695·8	590·13	23·65

NOTES.—*Power* at 2d. per k.w.h. *Depreciation* at 10 % per annum. Insurance 1 % per annum.

ESTIMATED ANNUAL COST OF OPERATING AN EDISON 10,000 LB. ELECTRIC TRUCK IN LONDON.

	Per year. 300 days.	Per day.	Per mile.
FIXED CHARGES.	£	d.	d.
Depreciation at 10 %	107·0	85·4	3·57
Interest at 3 %	32·1	25·7	1·07
Fire Insurance at 1 % *	10·7	8·54	0·36
Third Party Risk *	20·0	16·00	0·66
Total	169·8	135·64	5·66
RENEWAL CHARGES.			
Battery (Edison 60-cell A12) ..	12·0	9·59	0·40
Tyres	51·5	41·20	1·72
Chains *	11·6	9·28	0·39
Gears and Sprockets *	15·8	12·62	0·53
Bearings *	8·6	6·87	0·29
All other parts *..	10·0	8·00	0·33
	109·5	87·56	3·66
GARAGE CHARGES.			
Electric Power at 0·5d. k.w.h. ..	25·0	20·00	0·83
Rent, etc.	16·4	13·16	0·55
Garage Labour	18·6	14·88	0·62
	60·0	48·44	2·00
Driver	75·0	60·00	2·50
Grand Total	414·3	331·24	13·82

NOTE.—Items marked * are taken on the same basis as in America. This is not strictly just, as replacement cost is greater in the States. The mileage per day—24—is lower than need be the case, as a truck of this size can be run easily 45 miles per day in heavy work, thus reducing the depreciation account, etc, etc.

TABLE II. (*a*).

Make.	Loading capacity in lbs.	Wheel-base.	Tires.	Final Trans-mission.	Weight com-plete. lbs.	Battery.			Miles per charge.	Max. speed in M.P.H.
						Make.	Capacity.	Weight. in lbs.		
Bailey ..	300	106″	34″ × 4″ P.	Side-chains	2,200	Edison	150 A.H.	840	60–80	20
Baker ..	500	80″	34″ × 3½″ P.	Shaft-bevel	2,350	Lead	—	—	75	20
C. T. ..	500	85″	36″ × 2½″	Shaft-worm	2,950	Edison	150 A.H.	840	—	15
G. V. ..	750	76″	32″ × 2½″	Side-chains	3,000	G.V. Lead.	104 A.H.	840	45	12
Ward ..	700	72″	30″ × 2½″	Side-chains	—	Lead	—	—	50–60	—
Argo ..	1,000	86″	34″ × 3″	Shaft-bevel	3,000	Opt.	150 A.H.	1,000 L. 840 E.	40–50	13
Baker ..	1,000	85″	34″ × 3″	Side-chains	3,200	Opt.	150 A.H.	—	50	14
C. T. ..	1,000	90″ or 100″	36″ × 3½″ 36″ × 3″	Shaft worm	3,600	Opt.	—	—	40	11
Detroit ..	1,000	80″	32″ × 2½″ 36″ × 3″	Side-chains	3,000	Edison	150 A.H.	840	55	12
Fritchel ..	1,000	90″	32″ × 3½″ 34″ × 4″	Shaft-bevel	—	Fritchel L.	135 A.H.	1,000	80 ?	15
Lansden	1,000	96″	36″ × 2½″	Side-chains	2,750	Edison	150 A.H.	840	55	14
Urban ..	1,000	86″	36″ × 3″ S.	Side-chains	2,400	Exide	165 A.H.	—	40	15

TABLE II. (*b*).

Make.	Loading capacity in lbs.	Wheel-base.	Tires.	Final Trans-mission.	Weight com-plete. lbs.	Battery.			Miles per charge.	Max. speed in M.P.H.
						Make.	Capacity.	Weight. in lbs.		
Walker	1,000	—	32″ × 2½″ 34″ × 3″	Epicyclic internal gear	—	Opt.	—	—	—	15
Jacto ..	1,000	84″	32″ × 3″	Side-chains	2,850	Opt.	150–160 A.H.	—	40	12
Ward ..	1,000	84″	34″ × 3″	Side-chains	3,000	Opt.	150 A.H.	—	45–60	12
Waverley	1,000	91″	34″ × 2½″	Shaft-bevel	3,425	Opt.	150 A.H.	—	50	14
G. V. ..	1,000	87″	36″ × 2½″	Side-chains	3,500	G.V.	100 A.H.	1,255	45	12
Borland ..	1,500	93″	34″ × 4″	Side-chains	3,100	Exide	116 A.H.	1,200	50	15
Walker ..	1,500	—	34″ × 3″ 38″ × 3½″	Epicyclic internal gear	—	Opt.	—	—	—	10
M. & P. ..	1,500	100″	30″ × 3″	Side-chains	3,400	Gould	130 A.H.	900	45–50	14
Argo ..	2,000	96″	35″ × 3½″	Shaft-bevel	3,400	Opt.	160–185 A.H.	—	40–50	13
Atlantic ..	2,000	102″	34″ × 3½″ 34″ × 4″	Side-chains	5,300	Opt.	—	—	55–60	10
Baker ..	2,000	102″	34″ × 3½″	Side-chains	3,800	Opt.	—	—	50	12
C. T. ..	2,000	100″	36″ × 3½″ 36″ × 4″	Concentric Epicyclic	4,500	Lead	—	1,700	—	12

TABLE II. (*c*).

Make.	Loading capacity in lbs.	Wheel-base.	Tires.	Final Trans-mission.	Weight com-plete. lbs.	Battery.			Miles per charge.	Max. speed in M.P.H.
						Make.	Capacity.	Weight. in lbs.		
Detroit ..	2,000	84″	32″ × 3″ 34″ × 3½″	Side-chains	3,425	Edison	225 A.H.	1,260	55	11
G. V. ..	2,000	102″	36″ × 3½″	Side-chains	4,400	G.V.	138 A.H.	1,485	45	10
Jacto ..	2,000	84″	34″ × 3½″	Side-chains	3,300	Opt.	165 A.H.	—	40	10
Lansden	2,000	106″	36″ × 3″	Side-chains	4,000	Edison	225 A.H.	1,260	60	12
Urban ..	2,000	100″	36″ × 3½″ 36″ × 4″	Side-chains	4,050	Exide	165 A.H.	—	45	11
Ward ..	2,000	96″	34″ × 4″	Side-chains	5,600	Opt.	140 A.H.	—	40–45	10
Waverley	2,000	108″	34″ × 3½″	Shaft-bevel	4,400	Lead	189 A.H.	1,500	50	12
M. & P. ..	2,500	112″	34″ × 3″	Side-chains	4,100	Gould	170 A.H.	1,200	50	10
Detroit ..	3,000	96″	34″ × 3½″ 36″ × 4″	Side-chains	4,700	Edison	225 A.H.	1,260	50	10
Walker ..	3,000	—	36″ × 4″ 36″ × 5″	Epicyclic internal gear	—	Opt.	—	—	50	9

TABLE II. (*d*).

Make.	Loading capacity in lbs.	Wheel-base.	Tires.	Final Trans-mission.	Weight com-plete. lbs.	Battery.			Miles per charge.	Max. speed in M.P.H.
						Make.	Capacity.	Weight. in lbs.		
Atlantic ..	4,000	114″	34″ × 4″ 34″ × 3″	Side-chains	5,700	Opt.	—	—	50	10
Baker ..	4,000	120″	36″ × 4″ 36″ × 3″	Side-chains	5,900	Opt.	—	—	50	10
C. T. ..	4,000	116″	36″ × 5″ 36″ × 3½″	Concentric Epicyclic	5,200	Lead	—	2,000	—	1
Lansden	4,000	120″	36″ × 4″ 36″ × 3″	Side-chains	6,000	Edison	300 A.H.	1,800	45	10
Urban ..	4,000	118″	36″ × 4″ 36″ × 3″	Side-chains	5,200	Exide	220 A.H.	—	35	9
Ward ..	4,000	114″	36″ × 5″ 36″ × 3″	Side-chains	6,700	Opt.	252 A.H.	—	30–35	8
Waverley	4,000	114″	36″ × 4″ 36″ × 3″	Side-chains	7,800	Lead	216 A.H.	1,500	45	12

TABLE II. (*e*).

Make.	Loading capacity in lbs.	Wheel-base.	Tires.	Final Trans-mission.	Weight com-plete. lbs.	Battery.			Miles per charge.	Max. speed in M.P.H.
						Make.	Capacity.	Weight. in lbs.		
Walker ..	5,000	117″	36″ × 5″ 36″ × 3½″	Internal epicyclic gearing	—	Opt.	—	—	—	12
Atlantic	7,000	135″	36″ × 5″ 40″ × 4″	Side-chains	9,000	Opt.	—	—	40–60	12
Baker ..	7,000	134″	36″ × 6″ 36″ × 3½″	Side-chains	8,800	Edison	300 A.H.	1,800	50	9
C. T. ..	7,000	115″	36″ × 3½″	Concentric Epicyclic	8,250	Edison	300 A.H.	1,800	40–50	9
Detroit ..	7,000	132″	36″ × 5″ 36″ × 4″	Side-chains	9,600	Edison	375 A.H.	2,250	40	8
G. V. ..	7,000	128″	36″ × 6″ 36″ × 3½″	Side-chains	9,000	Lead	270 A.H.	2,410	40	8
Lansden	7,000	130″	36″ × 5″ 36″ × 3½″	Side-chains	8,000	Edison	375 A.H.	2,250	40	9
Urban ..	7,000	130″	36″ × 5″ 36″ × 4″	Side-chains	7,000	Exide	275 A.H.	—	30	8

TABLE II. (*f*).

Make.	Loading capacity in lbs.	Wheel-base.	Tires.	Final Trans-mission.	Weight com-plete. lbs.	Battery.			Miles per charge.	Max. speed in M.P.H.
						Make.	Capacity.	Weight. in lbs.		
Walker ..	7,000	125″	—	Internal epicyclic gearing	—	Edison	375 A.H.	2,250	40	9
Waverley	7,000	127″	36″ × 6″ 36″ × 3½″	Side-chains	9,000	Lead	270 A.H.	2,165	35	8
Atlantic ..	10,000	144″	36″ × 6″″ 40″ × 5″	Side-chains	10,500	Edison	450 A.H.	2,700	40	7
C. T. ..	10,000	132″	36″ × 4″ 36″ × 4″	Concentric Epicyclic	9,500	Edison	450 A.H.	2,700	40	7
G. V. ..	10,000	139″	36″ × 7″ 36″ × 5″	Side-chains	10,000	Lead	324 A.H.	2,790	30	7
Lansden	10,000	142″	36″ × 6″ 36″ × 4″	Side-chains	10,000	Edison	450 A.H.	2,700	40	7
Waverley	10,000	136″	36″ × 7″ 36″ × 5″	Side-chains	11,700	Lead	324 A.H.	2,790	35	7

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The fo machines in use at the end of the period, December, 1911, only city, 700 lbs.; four machines, capacity, 1,500 lbs.; four machir Edison batteries, the others having lead batteries.

	Miles Travelled.	Average K.W.H. per Mile.	Average Miles per Day per Wagon in Service.	Days in Service per Wagon per Month.
January, 19 3	617	·555	26·8	23·0
February 8	1·197	·590	24·9	24·0
March .. 4	2·329	·454	30·6	25·5
April .. 6	2·073	·429	26·6	26·0
May .. 1	2,215	·426	29·5	25·0
June .. 4	2,269	·415	29·1	26·0
July .. 8	3,136	·422	32·3	27·7
August .. 9	3,660	·420	28·4	25·8
September 3	4,175	·423	32·4	25·8
October .. 5	5,080	·419	32·3	26·2
November 4	5,094	·422	34·0	25·0
December 8	4,119	·418	27·5	26·0
January, 19 7	6,427	·419	25·4	22·5
February 2	5,353	·540	26·7	20·0
March .. 4	6,620	·436	30·5	21·7
April .. 6	7,296	·445	31·1	23·4
May .. 9	6,995	·470	29·0	23·8
June .. 8	9,919	·427	31·4	26·0
July .. 9	9,226	·494	30·7	25·0
August .. 9	9,552	·452	30·2	25·0
September 3	9,888	·435	30·7	23·0
October .. 7	10,891	·452	30·5	24·1
November 7	10,762	·544	30·1	22·3
December 7	10,715	·612	28·8	22·0
January, 19 7	10,584	·553	28·0	23·4
February 7	9,449	·635	26·4	21·1
March .. 8	12,311	·587	27·7	25·0
April .. 7	12,671	·583	29·7	21·4
May .. 7	14,055	·491	31·9	22·1
June .. 7	15,171	·487	32·8	21·1
July .. 9	15,197	·547	33·1	20·9
August .. 0	17,307	·475	32·8	22·0
September 9	16,589	·464	33·6	19·0
October .. 6	19,102	·476	31·6	21·6
November 3	19,863	·492	30·9	21·4
December 0	20,731	·518	30·0	23·0
Totals 1	320,838			
Average co service p 0	775	·495	30·5	22·6
Average c mile ..	—	—	—	—

It wil nse, and casualty insurance is $16·47 per month, and 2·1 c. other operating costs total $ 141·79 per month, or 18·3 c. pe on at 10 per cent., total $30·72 per month, or 4 c. per mile. 88 per month, or 25·2 c. per mile.

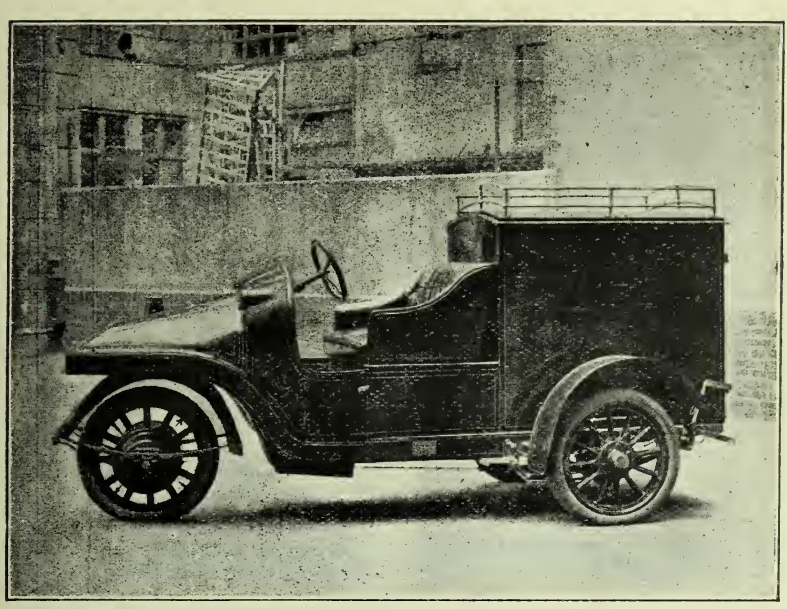
OPERATIVE COSTS OF ELECTRIC WAGONS IN SERVICE OF COMMONWEALTH EDISON COMPANY, CHICAGO.

The following statement commencing with January, 1909, covers a period of three years. Out of forty-three electric machines in use at the end of the period, December, 1911, only thirty are considered. The capacities of the wagons included in the report are as follows: Two machines, capacity, 700 lbs.; four machines, capacity, 1,500 lbs.; four machines, capacity, 2,000 lbs.; twenty machines, capacity, 3,000 lbs. Nineteen of the cars referred to are equipped with Edison batteries, the others having lead batteries.

	Number of Wagons Owned by Company.	Number of Wagons in Service.	Oil and Other Supplies.	Energy at 4 c. per K.W.H.	General Repairs.	Tire Expense.	Battery Expense.	Total.	Miles Travelled.	Average K.W.H. per Mile.	Average Miles per Day per Wagon in Service.	Days in Service per Wagon per Month.
			$	$	$	$	$					
January, 1909	1	1	10·75	13·68	—	—	—	24·43	617	·555	26·8	23·0
February	2	2	17·96	23·92	2·10	—	—	43·98	1·197	·500	24·9	24·0
March	3	3	15·26	42·28	—	—	—	57·54	2·329	·454	30·6	25·5
April	3	3	16·60	35·56	—	—	—	52·16	2·073	·429	26·6	26·0
May	3	3	·85	37·76	—	—	—	38·61	2,215	·426	29·5	25·0
June	3	3	2·00	37·64	—	—	—	39·64	2,269	·415	29·1	26·0
July	3	3	39·46	52·92	—	—	—	92·38	3,136	·422	32·3	27·7
August	5	5	13·90	61·48	3·21	1·50	74·90	154·99	3,660	·420	28·4	25·8
September	5	5	·50	70·60	7·59	1·50	17·06—Cr.	63·13	4,175	·423	32·4	25·8
October	6	6	3·50	85·16	13·24	3·25	16·70	121·85	5,080	·419	32·3	26·2
November	6	6	49·80	85·96	28·39	207·25	39·74	411·14	5,094	·422	34·0	25·0
December	6	6	15·20	68·80	7·08	—	—	91·08	4,119	·418	27·5	26·0
January, 1910	8	8	8·26	77·64	186·56	123·00	26·81	422·27	6,427	·419	25·4	22·5
February	10	9	7·60	115·64	42·28	—	—	165·52	5,353	·540	26·7	20·0
March	10	8	10·75	115·56	211·83	117·51	410·79	866·44	6,620	·436	30·5	21·7
April	10	9	28·87	129·76	57·53	—	—	216·16	7,296	·445	31·1	23·4
May	10	9	23·55	131·56	91·66	—	102·72	349·49	6,995	·470	29·0	23·8
June	12	12	23·08	169·48	184·22	64·00	—	440·78	9,919	·427	31·4	26·0
July	12	12	153·44	182·32	29·11	290·64	2·78	658·29	9,226	·494	30·7	25·0
August	12	12	53·24	172·80	56·56	—	150·61—Cr.	131·99	9,552	·452	30·2	25·0
September	14	13	45·13	171·92	115·32	1·50	280·46	614·33	9,888	·435	30·7	23·0
October	14	14	96·96	197·00	153·84	317·50	419·87	1,185·17	10,891	·452	30·5	24·1
November	16	14	27·98	234·04	313·71	122·32	9·02	707·07	10,762	·544	30·1	22·3
December	17	15	70·68	262·40	318·31	176·04	9·14	836·57	10,715	·612	28·8	22·0
January, 1911	16	15	256·50	234·08	184·24	48·79	213·06	936·67	10,584	·553	28·0	23·4
February	17	15	62·36	239·96	193·61	46·35	301·99	844·27	9,449	·635	26·4	21·1
March	19	17	36·20	289·28	249·56	200·61	132·83	908·48	12,311	·587	27·7	25·0
April	20	17	146·72	295·32	435·12	44·21	—	921·37	12,671	·583	29·7	21·4
May	20	17	218·46	276·00	279·01	96·27	98·83	968·57	14,055	·491	31·9	22·1
June	22	18	114·52	295·12	652·35	84·36	730·82	1,877·17	15,171	·487	32·8	21·1
July	22	18	·55	332·60	194·41	122·03	16·00—Cr.	633·59	15,197	·547	33·1	20·9
August	24	19	44·58	328·68	512·08	301·10	1,362·06	2,548·50	17,307	·475	32·8	22·0
September	26	20	56·89	307·80	78·52	299·63	205·85—Cr.	536·99	16,589	·464	33·6	19·0
October	28	23	12·51	364·08	166·39	332·12	113·46	988·56	19,102	·476	31·6	21·6
November	30	26	217·39	390·56	481·77	416·68	139·43	1,645·83	19,863	·492	30·9	21·4
December	30	28	235·34	429·24	316·67	267·86	16·79	1,265·90	20,731	·518	30·0	23·0
Totals	—	414	$2,137·34	$6,358·60	$5,566·27	$3,686·02	$4,112·68	$21·860·91	320,838			
Average cost per car in service per month	—	—	$5·16	$15·36	$13·44	$8·91	$9·93	$52·80	775	·495	30·5	22·6
Average cost per car mile	—	—	0·7 c.	2·0 c.	1·7 c.	1·1 c.	1·3 c.	6·8 c.	—	—	—	—

SUMMARY.

It will be seen from the above figures that the total General Expense including supervision, wheel tax and state license, and casualty insurance is $16·47 per month, and 2·1 c. per mile; Operating Expenses including driver's salary, washing, oiling and minor repairs, garage expense and other operating costs total $ 141·79 per month, or 18·3 c. per mile; Fixed Charges including interest at 6 per cent., taxes at 1½ per cent., insurance at 2 per cent. depreciation at 10 per cent., total $30·72 per month, or 4 c. per mile. Fixed Charges on garage, land and building are $5·90 per month, or 0·8 c. per mile, making a grand total of $194·88 per month, or 25·2 c. per mile.

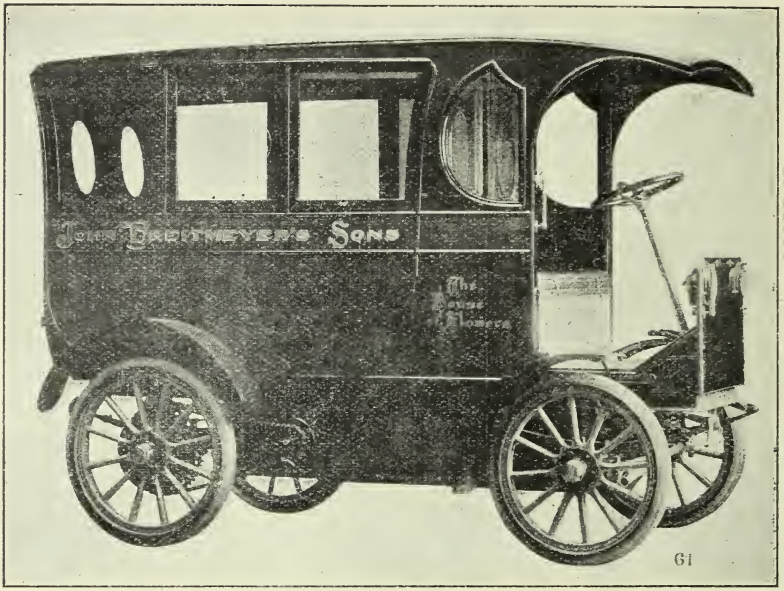


View of Gebhardt and Hahorn Front Wheel Delivery Van.

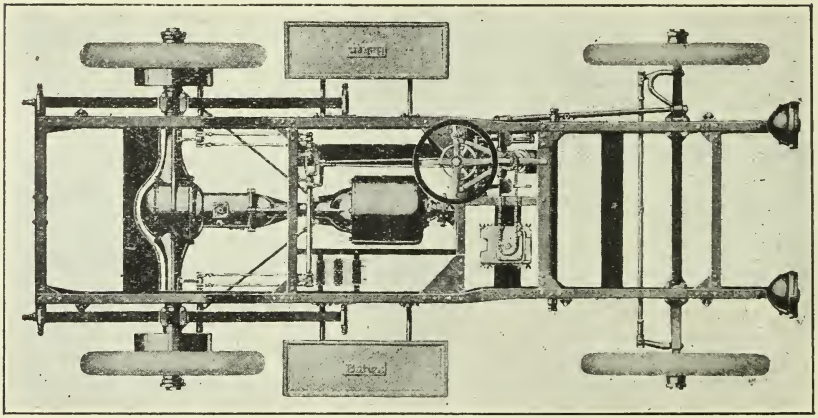
FIGURE 55.

View of extra heavy Electric Truck carrying 12,000 lbs. Four-motor drive. Turning radius 18′ when steering by front and rear wheels. Speed on level, 7 M.P.H. Miles per charge about 30, fully loaded. Wheel base, 20 feet. Overall length 32 feet.

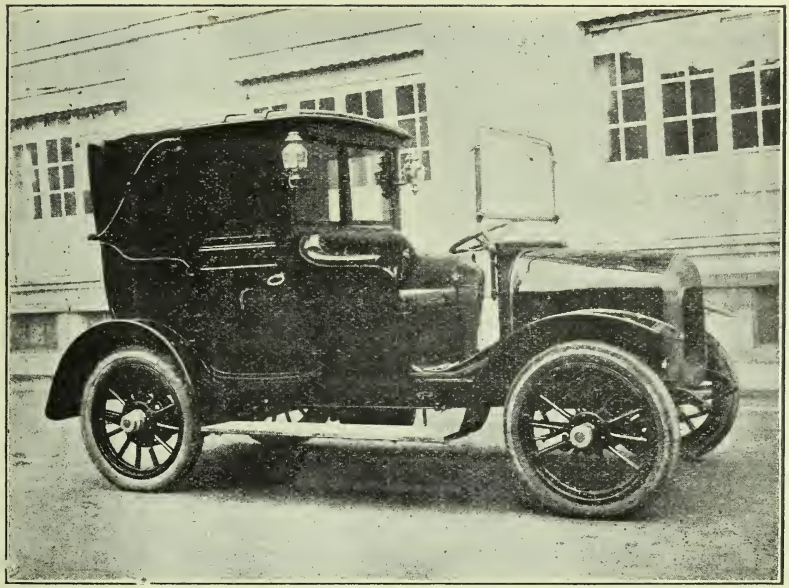
FIGURE 56.



Anderson 1,000 lb. Van, equipped with Edison Batteries.
FIGURE 57.

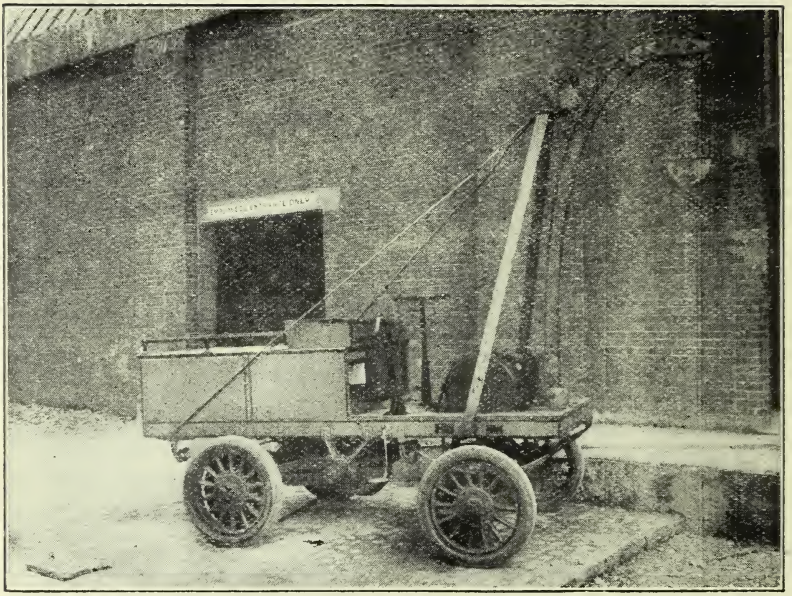


Plan of Baker Pleasure-Car Châssis, showing General Arrangement.
FIGURE 58.



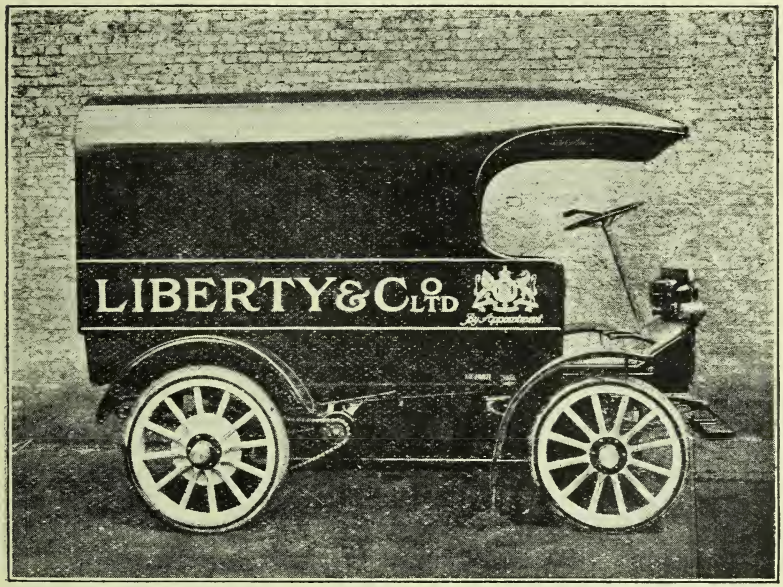
The first Edison Electric Taxi in Paris. Constructed by M. De Dion-Bouton, to the designs of J. F. Monnot.

FIGURE 59.



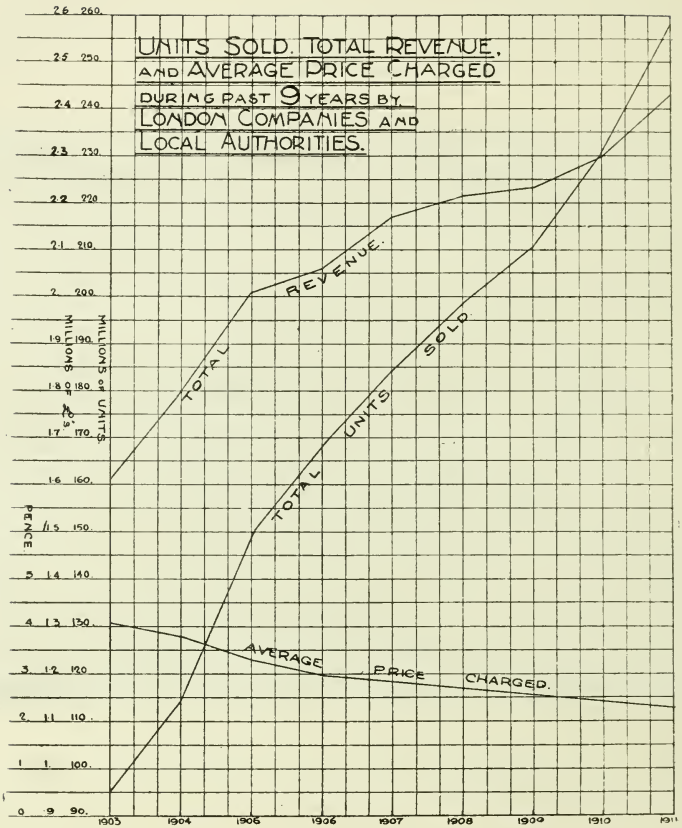
Edison Battery Works Crane, in use at B.T.H. Company's new Lamp Works at Neasden. This type of Crane can handle up to 2 tons at one trip and has shifted as much as 1,000,000 lbs. a distance of 600 feet in nineteen hours.

FIGURE 60.



Edison Accumulator Light Delivery Van.

FIGURE 61.



Showing *fall* in average price of Electricity.

FIGURE 62.

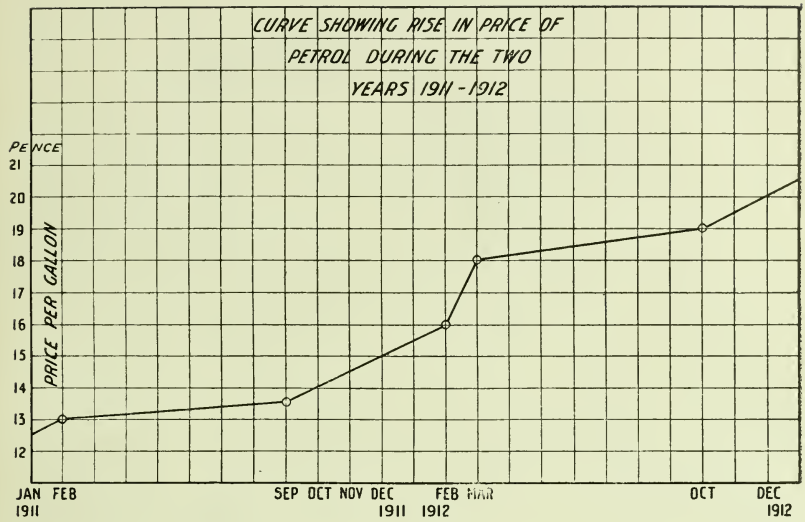
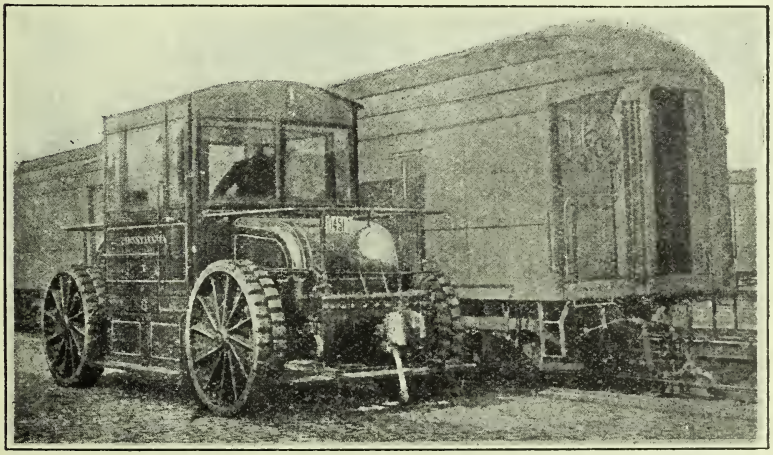
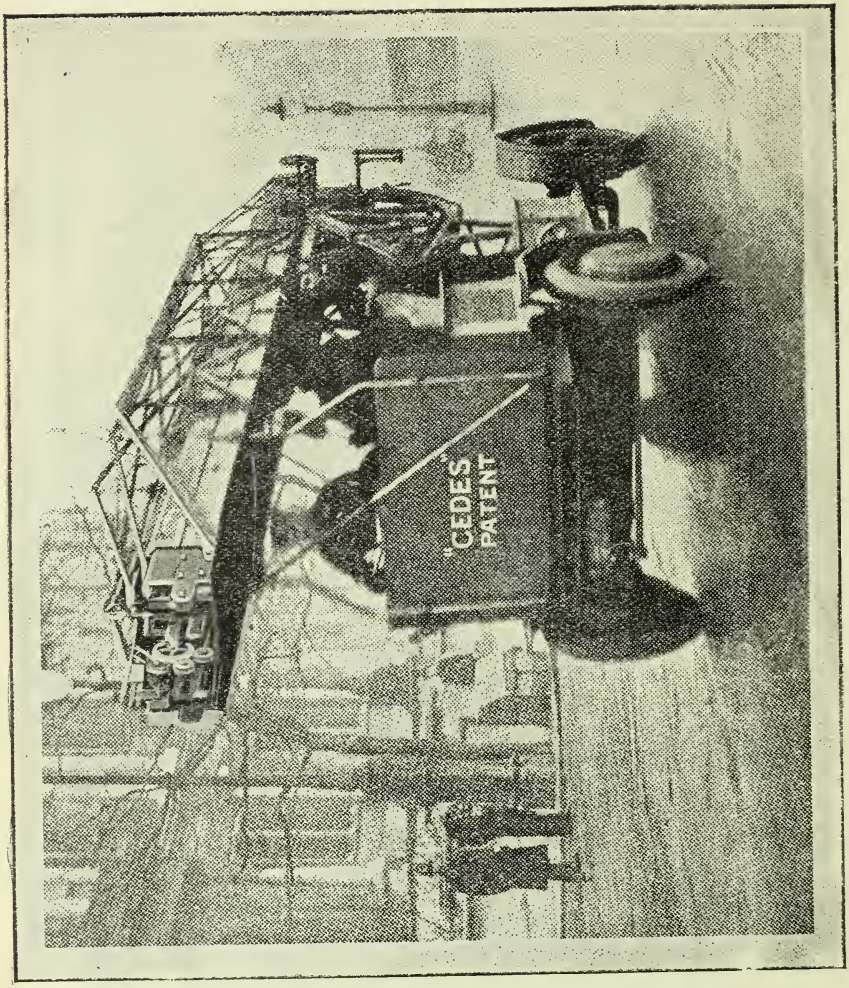


FIGURE 63.

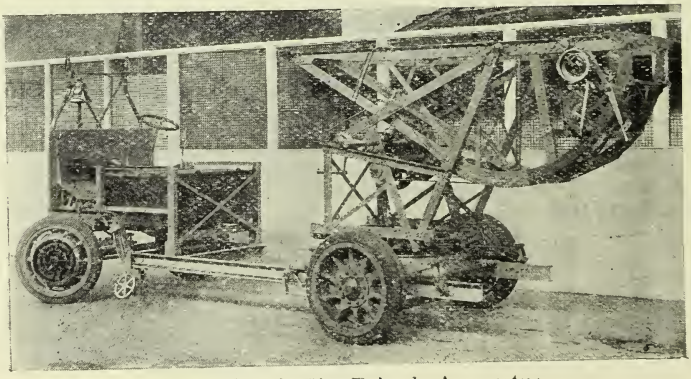


Large Edison Battery Tractor, designed by Mr. Buckwalter, of the Pennsylvania Railroad, for Railway Car Shunting. Battery Equipment 80 Edison A12 cells, Capacity 48 K.W.H., Weight 3,600 lbs. Drive through 1 to 40 gear to Two Motors of 10 to 25 H.P. each. Weight 28,850 lbs. Length 22 feet. Miles per charge 40. Speed 4 M.P.H.

FIGURE 64.



Cedes Electric Fire Brigade Apparatus.
FIGURE 65.



Cedes Electric Fire Brigade Apparatus.
FIGURE 66.

DISCUSSION.

Mr. A. Hugh Seabrook (Chief Electrical Engineer, Marylebone) said he would not discuss the various types of batteries or various types of battery vehicles, but he wished to bring before the attention of the Association the great importance of the electric vehicle from the public health point of view. The authors were very much to be praised for the fair way in which they had dealt with the various types of vehicles, for although naturally they were keenly interested in one particular type of battery, they had gone into the whole question thoroughly and not omitted to mention other makes. He personally had looked into the question a good deal, and it seemed that the user must decide whether to pay a good price for the battery and a small annual maintenance charge, or a small price for the battery and a high annual maintenance charge. This was the main difference which everyone who was going to use these vehicles would have to consider as between the lead and the Edison types of battery. In this country we were the first to develop electricity supply for lighting, and we were the first for power; other countries followed. There was no question that the members of the Association were doing infinitely more in the way of heating and cooking than was being done in any other part of the world. He personally had been keeping a particularly close watch on all the developments that were happening, and there was no doubt whatever that we were still to the front, but for some reason which he was unable to explain or fathom, we were absolutely behind every civilised country in the world on this question of self-contained electrically propelled vehicles. The reason was most difficult to understand. It was not because of roads. Our roads were surely as good and better than those of other countries. The price of current in this country compared very well with any other country in the world, and he was rather inclined to think that it had something to do with the attitude of the British battery makers. He was not going to advocate any particular make of battery, but he did think that people such as the Company the authors represented, who took the trouble to boost the business up and draw attention to it, were entitled to as big a financial gain as they could get from their efforts. The supine attitude of the British battery makers was extraordinary. They either condemned electrical vehicles altogether, or they damned them with faint praise. He could not understand it, because in the British battery business there were some of the smartest and cleverest men in the electrical industry, and why they persistently

ignored and decried the possibility of electricity for this purpose it was most difficult to understand. Electrically propelled vehicles should appeal to municipalities particularly and more than to the private user. In important residential districts and seaside towns surely hygiene must be taken into consideration. Mr. Christie, of Brighton, would probably tell the meeting that he had been making some very interesting experiments there, and there was a possibility of sweeping the whole of the horse traction out of the municipal service in Brighton. That was obviously as it should be, provided the cost of electrical vehicles was not outrageous. It was not right that a place like Brighton should have such an insanitary method of traction such as horse traction, and neither should other important residential districts such as Harrogate. Some useful tests had been made recently in his own district with another class of electrical vehicle called the F.R.A.M., which was referred to in the paper. This was the only electric vehicle of which he had had actual experience as to cost. It was a French machine, and it had been put at the service of the Public Health Service Department of Marylebone for some months, and it had been running for seven or eight days for various purposes. They loaded it up to 1½ tons and ran it out on what they called a "slopping" round and a dust collection round, and also a street sweeping round. The dust collection of course, meant stopping the usual number of times which was about 1,400 per day. For the sweeping it had to drag a makeshift arrangement of a couple of horse drawn brooms. These were very difficult conditions, the starting and stopping, and the weight and pull of the brooms. But in spite of that, throughout the whole tests, the units put into the machine were less than one unit per mile run, and the efficiency of the battery motors and gear was approximately 65 per cent. He would like to say a word with regard to tariffs. This was a new business, but there was no necessity in the case of this new business, as there was the necessity in the last class of new business, electric cooking, to make a very low rate. He asked members of the Association who were considering what to charge, to take into consideration the price they *could* get. It was no earthly good offering a tariff for cooking, heating and power, which was not competitive with other agencies. In the case of heating and cooking, he held the opinion that no big business would be done at less than ½d. where gas was 2s. 6d. or near it, but in the case of vehicles, a very different position arose, and he believed that in settling these tariffs for various classes of business, they were quite entitled to consider what the value of the supply was to the class of business,

and to charge accordingly. It would be quite ridiculous to offer an all-round competitive price of ½d. per unit for electric vehicles, because in his opinion the value of the service was about 1d. for even large commercial purposes. A firm buying 50 or 100 of these cars of course would come in under special contract, but he did not believe that even the authors would say that an all-round retail price of 1d. to 1½d. per unit would have any effect as regards restricting the use of these vehicles. There was still an urgent necessity for encouraging the use of electricity for all purposes. Possibly they were not out of the wood yet with regard to lighting. His own district was largely a lighting district, and his lighting revenue was a class of business he had to keep a very close watch upon. For instance, during the last twelve months the introduction of the new 16 c.p. metal filament lamp—which possible would not affect an ordinary district very much—had dropped his revenue considerably more than £7,000, so that he was keenly on the look-out for all other uses of electricity, because the last word had not been said with regard to the efficiency of electric lamps, and still further considerable reductions in the lighting revenue in the future must be looked for.

Mr. W. W. Lackie (Chief Electrical Engineer, Glasgow), said that in November last year the Glasgow Corporation ordered an electrically propelled commercial vehicle which was delivered in February of this year. It was sent to Glasgow by rail, and the man who was sent to the station to get it, and who had never seen the vehicle before, drove it away without any trouble whatever. It cost £630 and weighed 33 cwt. empty and carried a load of one ton. With one charge it ran from 37 to 40 miles, and had done this regularly for four months during which period it had run from 550 to 600 miles at a cost per mile of 0·6d. This compared with 1·2d. for a similar petrol car at a time when petrol was very much cheaper than it is to-day, so that there was no occasion to sell electricity under 1d. per unit for charging, at the present price of petrol. He was warned that this electric car would not climb hills, and that in America the streets were much more even than in Scotland. This car, however, would go up hills in Glasgow that no horsed vehicle would think of going up. There was a famous test hill in the district of Glasgow, and this car was able to drive up it with ease. They previously had horse vans which cost £14 each per month to run, but the cost of running this electric car and allowing 20 per cent. depreciation, was £19 per month, but it should be pointed out that this car was doing the work of two vans so that the Corporation was well

in pocket over it. The other strong point about the vehicle was that the horse van was only available for use for 24 hours, but the electric vehicle could be used on Sundays and at night for special jobs for which the horse vans could not be got out. The other great thing about it was that the charging of the battery could be done at other times than peak load times. The cost of working the vehicle at 1d. per unit worked out to £26 per annum which was equivalent to three domestic consumers; consequently there was every encouragement to do all they could to develop the use of these vehicles. The cost of 0·6d. previously mentioned was with current at 1d. per unit.

Mr. J. Christie (Chief Electrical Engineer, Brighton), said that like Mr. Seabrook he was in charge of an undertaking which depended very largely for the greatest part of its revenue on lighting, and owing to the increased efficiency of lamps, he too, was losing revenue in spite of adding on new business at a greater rate than before. He had got all the motors that were to be obtained, and therefore must look for side lines such as cooking and other methods of applying and using electricity. In Brighton there was a fleet of sixteen or eighteen motor omnibuses driven by batteries, owned by the local omnibus company, but which under a bill recently obtained by the Corporation, would be transferred to them. The routes for these omnibuses were soon to be changed for the running of trolley omnibuses, and in consequence, he would lose the revenue from the charging of the 'buses. Consequently, he had given consideration to the question of adapting the electric buses for several municipal purposes such as dust-carting, washing, ambulances, etc., and he hoped that his Committee would be able to follow out his suggestions, and in this way assist him to retain a very large portion of the revenue which he at present derived from the 'bus company. Transferring these vehicles to the works department would enable that department to get their work performed more efficiently and at a less cost than for horse hiring. With regard to the rate for charging, he thought 1d. was quite low enough. The Brighton 'bus company had been paying this in the past, and he had heard no complaints of an excessive rate as compared with petrol per car mile run. It behoved all supply engineers to try and develop this class of business because there was an enormous field for future development inasmuch as the vehicles could be charged at times when the generating plant might be almost absolutely idle. In this way they could afford to supply at a very low rate, and the supply of current in this way would all tend to reduce

works costs and to improve the load factor of the station. During the Paris visit of the Institution of Electrical Engineers, he visited one morning the Municipal Department which controlled the sweeping of the streets and the removal of the dust from the houses to the dust destructor. The engineer who showed him round gave him a most interesting demonstration of one of these vehicles used in this country, and there was no question as to their mobility and efficiency ; they far surpassed anything he had seen before, and the Paris authorities were so satisfied, that they were placing an order for several hundred vehicles, and in a short time the whole of the work of the city could be carried out by self-contained electrically propelled vehicles. In that case, current was being bought from a Company at a substantially higher price than obtained in England under ordinary conditions.

Bailie Smith (Chairman, Glasgow Electricity Committee), suggested that the right way to introduce electric motor traction was for the Electricity Department to use vehicles themselves and to get the results of tests which would enable them to recommend it to other Committees of their Corporations. In Glasgow the Electricity Committee had adopted the vehicle, and the first Committee which the electric vehicles were to be recommended to, was the Health Committee for their motor ambulances connected with infectious hospitals.

Mr. F. Ayton (Chief Electrical Engineer, Ipswich), expressed the opinion that the electric battery vehicle business from a central station point of view was going to be just as important, if not more, than the electric cooking and heating business. The rate for charging was well worth discussing, because he felt that they would all realise later on the importance of having some unanimity all over the country in this matter, inasmuch as if any impetus was to be given to the use of the pleasure vehicle it must of necessity mean that people would want to go from one town to another to get their vehicles charged without difficulty, and without undue expense. Electric supply engineers were directly concerned in the successes or failure of this method of traction, and no stone should be left unturned to make it a success, if it could possibly be made one. The right thing to do, he thought, was for the Association to give a special lead in this matter, and he suggested the formation of a special Committee to go into the question in co-operation with the manufacturers. There were many points which ought to be settled at an early stage ; for instance, the uniformity of the charging voltage, the

question of the standardisation of the charging connections, the rates, and they should go even further and investigate the most suitable speeds to recommend for the various motors, because they should not act too much on the experience from America. They all knew what happened in connection with the early ventures in tramway work in this country. American practice was copied in every detail, which proved to be a mistake, and they had to change their designs subsequently in a good many details. Therefore he felt that a Committee such as he had suggested could do very good work. It would also be of help to some of the engineers of the smaller undertakings, who might have a difficulty in convincing their Committees of the necessity of adopting a reasonable price and giving proper facilities for charging. With regard to charging facilities was it not worth while discussing as to how we should start ? Should supply station engineers start by inaugurating a garage or some place where cars could go to be charged ? He had spoken to some of his automobile friends in Ipswich on this matter, and from what he could gather so far, they would not move very quickly in this matter. They were too much wrapped up in the petrol vehicle. They did not understand the electric vehicle and were afraid of anything electrical. They had quite enough trouble as it was with the ordinary electric circuits on the petrol vehicle, and he felt convinced that they would have to make a very strong move in the matter. It would probably be necessary to establish charging stations in each town, and, perhaps, go a little further and at the first outset do any repairs which might be necessary. He admitted this was a big question, but it was one which his suggested Committee might go into and report to the Association as to the conclusions they had come to. He would like to hear Mr. Watson's views as to how to start. In regard to the details of design, he noticed the paper said that designers were in favour of the chain drive for commercial vehicles. He was inclined to doubt the wisdom of that. He was attending the other day a meeting of the tramway managers section of the Municipal Tramways Association at Sunderland, where they had a very interesting discussion on motor omnibuses. The manager of the Bradford tramway system, Mr. Spencer, who also ran trolley omnibuses, told him that the buses which he had and which were provided with chain drive, were going to be scrapped for the reason that the chain drive had proved a failure. The new buses would be worm driven, and as they probably knew, the worm drive in petrol motor-cars working to-day had proved an absolute success where the worm had been properly

designed and made. On the new railless buses at Bradford, therefore, there would be two motors, one on each side, each motor independently driving one of the wheels through its own worm gear, and he would like to hear whether Mr. Watson did not think in the light of what he had said that the worm drive was probably the better method. With regard to the motors, they ought to be very careful and do everything possible to avoid startling failures with these vehicles, because it would be a very bad advertisement and cause a serious set-back to the progress of the business, and here again something might be done in the way of standardisation in ratings, and especially in bearings was it necessary to be very careful. He had been through all the trouble with the tramway motor, and had finally come to the conclusion that the only satisfactory system of lubrication for ordinary bearings on tramway work was oil.

Mr. J. W. Beauchamp (West Ham), was afraid that he could not add very much to the discussion, but thought that if the paper had been published as a text book there would have been no trouble in selling it very freely. He thought the Association ought to have a paper on the subject next year if only to report progress. Personally he could not say that they had sold any vans in West Ham, but they had had a large number of enquiries, about a dozen, and he believed they would get some business before long. The use of these vans should first be pushed for shifting heavy loads at low speeds leaving the pleasure side to look after itself.

The future of the thing was really in the hands of municipalities who could easily give it a start if they would. All municipalities had a lot of work in shifting heavy loads at low speeds, and by utilising the vans in this way they could prove the economy of them. Mr. Seabrook had already mentioned that such vehicles had been used in London for similar purposes, and the list in the paper of the vans used by the Commonwealth Edison Company was very striking and seemed to prove the advantage of the use of such vans by every electric supply department. By utilising them and superseding the ordinary methods, for instance, of sending out jointers, etc., in big towns, it would be possible to save the cost of such a van several times over. With regard to a tariff he believed that $\frac{3}{4}$d. a unit was a very good one, and would bring in a revenue of about £25 a year, and as the vans could be charged off peak with very little arrangements indeed, the average load factor of charging these vans would be 40 or

50 per cent. The question of providing charging stations and things of that kind was one in connection with which they could begin almost immediately to compile a list of places where such facilities could be provided.

Mr. R. A. Chattock (Chief Electrical Engineer, Birmingham), said it was clear from what had been said that there was a very big business to be anticipated from this class of supply, and it was one well worth making a bid for. The only way in which electric supply departments could assist was by regulating their rates of charging to accommodate this class of supply. A penny per unit had been mentioned that morning as being a fair figure. He would like to know what the authors thought of that, because it was a very important point. A penny per unit was the ordinary charge for power now in most large towns, and that rate could undoubtedly be charged all day long, but he assumed on the top of that rate for current, the cost of the garage and the handling of the charging would have to be added. He did not know what this would amount to, but assuming that it was equivalent to ½d. per unit, he would like the author to say if 1½d. per unit would be sufficient to meet the requirements of the users. If less than 1d. was to be charged it would, in his opinion, be necessary to give a restricted hour supply for this lower rate, which could only be justified in this way. He was of the opinion that it would fully pay electricity supply undertakings to charge a less rate than a penny if they could restrict the hours of charging to night or to times in the day when the demand was slight. He did not favour the suggestion put forward by Mr. Ayton that municipalities should undertake the garaging and repairing of these automobiles. This was hardly within their province, and from enquiries which he had made in Birmingham, he was convinced that the ordinary garage proprietors were fully prepared to undertake this side of the business and to carry it through for the benefit of the public. If the garage proprietors could see big business in it and supply engineers could see big business in it, there was no doubt that the scheme would go forward and would be remunerative for both of them.

Mr. Sykes (Glasgow), objected to the argument of Mr. Seabrook that, from the outset, the correct price to charge for current was that which the vehicle user could afford to pay compared with petrol costs. It would be quite time to manipulate the price of current when the electric vehicle had got firmly established.

It would be a pity to " kill the goose which laid the golden egg " and if it were attempted to charge the vehicle industry on this basis there would quickly be no industry and—a few odd vehicles were of no use to station engineers. A sounder procedure would be to consider exactly what it cost to cater for this particular business and make such charges as would yield a reasonable margin over costs. For the purposes of this supply there would be no mains to lay and no increased establishment charges, in fact, practically no cost beyond fuel. It would be purely, or at any rate largely, a steady night load. Mr. Chattock's suggestion of a restricted hour supply was ideal, because there could then be cheap rate charges for those people who took current during the night time, whilst those people who took current at peak times could be made to pay for it at a correspondingly higher rate. This would probably meet everybody's wishes.

Mr. L. B. Hogarth (Chief Electrical Engineer, Morecambe), expressed his pleasure that a paper on Electric Vehicles had been read before the Association. It was a question which had interested him for a little while, as his Corporation was considering the question of the electrification of the Morecambe tramways and wished, if possible, to avoid adopting the overhead system. They regarded the alternative of adopting the electric accumulator as a possible one, but the question was which would be the cheapest and best method for a small Corporation to adopt. As probably several of them knew they had in Morecambe petrol tramcars running on a route about a mile long, but if anybody suffered from liver complaint a ride on these cars occasionally would either kill or cure it. From the figures that had been obtained from the Edison Storage Battery Company, he thought that there was a great future for the system if they could only extend their guarantee for a period of three or four years, especially in districts where traction extensions were contemplated. The advantage of the electric battery vehicle was that by allowing an overlay of about ten minutes, the vehicles could all be charged up in the day-time ready for running during the evening, thus necessitating no interference with the peak load at all.

The President said the meeting must have been disappointed at not having heard anything from battery makers on the question. The whole question rested on that and as he understood that there were representatives present of the leading battery

makers he was sure the meeting would be pleased to hear them during the few minutes which remained for the discussion to continue.

Mr. F. W. Crawter (Chloride Electrical Storage Co.) said he did not propose to speak about the battery part of the paper so much as the electrical vehicle as a whole which was of a peculiar interest to him because he believed he was the first driver of an electric automobile in this country which was as far back as 1888. He believed the first electric vehicle which ran in London was one improvised by Professor Ayrton in 1885. Then came Mr. Radcliffe Ward's 'bus in 1886, and then the Immisch Company in 1888, 1889, 1890 made various vehicles although everyone was pleased that they were for export work when they were made. Mr. Seabrook had rather rubbed it into the lead battery makers, but as a lead battery maker he would like to rub it ito the central station men because until this year of grace, 1913, battery makers and central station people had not been working together as they might have done for putting electric vehicles on the market. It was no good people working alone in this matter, and both the battery people and the supply station people must work together. Therefore he welcomed heartily the efforts of the authors to popularise the electric vehicle. It had been popularised to a remarkable extent, particularly in America. He hoped, although he did not think it would, that it might go to the same extent here. His reason for this was that the conditions were not quite the same in America as in this country. There there were tens of thousands of private electric runabouts, and he did not think the pleasure vehicle would be developed in this country to the same extent, because in America there were large towns situated large distances apart, and the electric pleasure vehicle was used simply as a town vehicle. In London if a person had an electric vehicle to take him to his office five or six days a week, on the other day he might want to go to Wales. An electric vehicle at present would not take him there in one fell swoop; he would have to stop at various places for charging. If therefore, he had to have a petrol vehicle for his week-end driving, he would also naturally use it during the week, and except for purely town purposes he did not think the electric pleasure vehicle would develop very much, and it was for purely town purposes that he believed its application really lay. For commercial vehicles it was quite a different proposition. There was an enormous field, particularly in shifting heavy weights, for the electric vehicle, and if the supply people would only work together with the producers of such vehicles,

he was sure that good would result. One point in the paper was that the authors gave the average life of a lead battery as being 3,000 miles. This was about one-third of what it actually was. He believed the particulars the authors had got were from a system taking practically twice the watts per ton mile which modern practice would give. Another point was in the paper, reference was made to the wood separator as being cheaper than ebonite and equally effective, but wood separators were not employed on account of their cheapness, but because of the extraordinary effect which they produced in actual practice. He would like to conclude by congratulating the authors on the very fair way in which they had put their case.

Alderman F. Smith (Chairman, Liverpool Electricity Committee) asked as to the weights and speeds of the vehicles which were recommended for shifting heavy loads.

Mr. Crawter said that electric vehicles had been made to carry 8 to 10 tons at a speed of from 4 to 5 miles an hour.

Mr. F. S. Grogan (British Electric Transformer Co.) said that the question of the tariff had been tackled in a most businesslike spirit by Mr. Seabrook, and it was quite clear that the question must be divided into two items, namely, the pleasure vehicle and the commercial vehicle. The question of the tariff would be decided on the commercial side as between the engineer in the district and the commercial firm who were running the vehicles, as such arrangements could be made as would get the least charging prices during the night. With the pleasure vehicle surely it was a different matter altogether. A man might come along and say he had run out of juice and wanted more. He would come into the town in order to get electricity at any time of the day or night and they could not do that for a penny or anything like it. Might he suggest that station engineers should take this question in its infancy and go ahead on really commercial lines for the pleasure vehicle in order to get the enormous load which was waiting. For this reason he supported the suggestion by Mr. Ayton that a committee should be formed to work on co-operative lines so that they would be able to loan batteries ready charged from charging stations all over the country, and a pleasure vehicle could pay for a charged battery that would run him into another town where he could return it to the charging station there and take another. In this way he did not have to pay the capital cost on the battery whilst the charging stations could

loan out the very excellent battery which was now available and which involved low running costs and very little maintenance. By such a co-operative scheme as this they would be able to acquire a tremendous load for their power stations by supplying these cheap units.

The President said this question had occupied his attention some ten or twelve years ago, and he felt that if anything was to be done at all it would have to be done like the Clearing House for railways. Standardized batteries would have to be adopted, and the larger cars would have to have a larger number, and each central station would have a certain number of these batteries in their works ; a small town a few, and the larger towns a larger number, so that the owners of cars would, when arriving at a town, go to a central station where there would be facilities for taking out their battery and putting in a fresh one immediately. They would simply pay in an ordinary pass check, no money would pass, and at stated intervals the station engineers would collect from the central body the amount of money due to them, and the central station would be charged up with the number of batteries. It was a matter which he had had before him some years ago, and when Mr. Watson approached him a few months ago, it occurred to him then that a great deal of work could be done by getting together a representative committee such as Mr. Ayton had suggested. This Committee could do a great deal of the spade work which was necessary in order to bring about the enormous sale of current throughout the country which electric vehicles would require, and he would suggest that it should be a hybrid committee, not only amongst themselves, but consist of engineers of outside supply authorities as well, if they would join it. In conclusion he would tell a little story. Many years ago his Committee decided to put up a small launch "charging" station down the river. They ran a cable from the works a distance of 150 yards to the riverside, and when discussing the rate to be charged for current for launches, he suggested that as there was a launch-charging station on one of the islands up at Hampton it would be well to find out what that station was charging in order that, if possible, his Committee would fall into line in the matter of tariffs. He therefore sculled up there one evening and saw the engineer-in-charge. This particular charging station was at a great disadvantage because it had a little plant which had to start up whenever a launch wanted to be charged. He saw the engineer and told him that his Corporation was proposing to charge launches, and asked what the charge was in his case so

that if possible they could fix up the same. The reply was that this charging station charged 2s. 6d. per unit. He (Mr. Edgcome), explained that he was hardly likely to be able to charge such a price, and that probably after having once got a customer this particular charging station never saw him again, and consequently he could not recommend his Committee to fall into line on the question of tariffs if it was tied to 2s. 6d. The engineer-in-charge then mentioned that he was not tied to 2s. 6d., and mentioned a case of a man who had come down the river from Windsor, and was not sure if he had enough energy in his batteries to take him back again, and that he would like his batteries charged. The engineer at the charging station said he would put in enough current to take the man back to Windsor, but that his charge would be £1 1s. The owner of the launch was perfectly satisfied " and," said the engineer-in-charge, " I put in three units." He did not think, concluded Mr. Edgcome, that this particular charging station existed at the present time.

Messrs. Watson and Mitchell, replying in writing, say that whilst in the main Mr. Seabrook's remarks contain very appropriate criticisms regarding the present situation of electric vehicle enterprise in Great Britain, yet there are a few points which the authors would like to rediscuss. It is not quite true that the main difference between lead accumulators and those of the nickel-iron type is that existing between cheap first cost with high maintenance as against higher first cost with low maintenance, as this view would seem to indicate that the *ultimate* cost with either system would be identical.

A few figures will throw light on some of the differences existing between the two systems. Consider two approximately equal batteries, the one a lead-sulphuric consisting of 44 cells, the other a 60 cell nickel-iron-potash, both equipments giving about 11 k.w.h. In original cost, the lead cells would be about a third of the Edison, and might run with first rate supervision say between three and five thousand miles, after which a complete renewal would be necessary costing practically as much as the original battery. The Edison battery would run on a basis of 50 miles per day (for example a taxi-cab service) a distance of 60,000 *miles, during which time it is guaranteed* to need no plate renewal or repair and to maintain at least its rated output and efficiency—costing during this time only the small sum entailed by annual renewal of electrolyte (about four pounds per annum for an 11 k.w.h. battery) together with the expense of distilled

water for "topping" up. Very severe tests, however, indicate that the present type of Edison accumulator will not have fallen to its rated capacity even after 3,300 cycles of charge and discharge under normal conditions, which means that the aforementioned taxi battery would have propelled the car a distance of 150,000 miles without requiring any renewals or mechanical repairs and with its capacity not even then reduced below original rating. Hence it is evident that in the taxi service one could rely on *at the very least* a life of ten years for the Edison Accumulator working day after day for 300 days per annum. Hence it is obvious that the nickel iron cell must be cheaper to operate in traction service than cells of the traditional type. Moreover, with the Edison there is no necessity to keep a staff of battery hands in the garage, nor a battery expert, as upkeep is confined to a mechanical procedure of charging and simple supervision against allowing adjacent cells to become externally wet, thus rusting the steel containing cases.

Yet another point lies in the fact that it would be futile to keep spare batteries in an Edison electric garage—there being no need to unship these cells, excepting once a year to pour out the spent electrolyte. It is made not possible to get "inside" Edison cells for any other purpose ; because never necessary. If repairs were ever likely to be needful, these cells would have been designed to allow for this factor. Enough has been stated to indicate that there is more than a mere difference in price—great as this is in favour of the new type—between the two types of accumulator. The choice lies between buying a small amount of service for a fairly small sum paid down, as against a much larger amount of service costing therefore a higher initial lump sum in the total but much *less per unit of service* in the end. Further advantages lie in the fact that whereas the lead cell depreciates steadily in capacity for at least two thirds of its useful life, the Edison increases in capacity for several years after it is first put into commission. Hence the *average service efficiency* and mileage per charge from a battery of given rating is considerably greater with the nickel-steel battery. This point is so fundamental that the authors may be excused for having dealt with it at some length.

It is not clear why Mr. Seabrook is not sympathetic to the *principle* of very low rates for energy for electric vehicle charging. Surely it is to the ultimate interest of every station engineer to do his best for the electric in the matter of tariffs. Mr. Seabrook

must have felt in a cautious vein when suggesting that station engineers should charge " what price they could get," as this attitude would end logically in no electrics and no current ! In reply to Mr. Seabrook's indirect query as to whether the authors would feel quite satisfied with a three-halfpenny or penny rate it seems that there are so many reasons why electrics should be treated as generously as the cooker that the matter is one for collective discussion. Cheap energy will, however, be such an enormously helpful argument to aid the popularizing of electrics that there seems to be an excellent case for applying the best traditions of the " point five " club to this new enterprise.

The authors are much interested to note the satisfactory service rendered by the 1 ton van purchased by Mr. Lackie for the Glasgow Corporation. In depreciating this machine at twenty per cent. per annum, however, an attitude most needlessly pessimistic is taken. Ten per cent. per annum would be an ample allowance for the chassis, the electric being the most long-lived of automobiles. It should be remembered that even petrol motor omnibuses have given as long as seven years' service in London—a duty exceeding the total duty of any electric in double that period. Again the frequent contention about " getting out of date," etc., is not likely to hold much justification in the case of an electric, for the reason that such machines incorporate already so many nearly perfected details—bearings, motors, chains, tyres, and the like being unlikely to develop much farther along the present lines. The figure quoted per mile, namely 0·6 of 1d., is a little high for this size of van, and represents the *input current* cost per mile at 1d. per unit. It is possible to run this van on 0·55d. per mile input.

So much has been heard of the " Brighton 'Buses " that it is to be hoped that Mr. Christie may some time see his way to give a paper on this interesting subject. A detailed account of the methods employed and results obtained in running these machines would have a unique value, as the service appears to have given satisfaction under conditions that compare very unfavourably with those existing when the electro 'buses ran in London. The severe gradients and relatively lower passenger density of Brighton must have taxed the system to its utmost—hence the added interest that lies in a successful issue of such experiment. Mr. Christie is to be congratulated upon having piloted such a difficult venture so well.

There is not the slightest doubt that the electric vehicle situation can be powerfully advanced in the manner Baillie Smith recommends. As soon as Corporations have satisfied themselves by practical trial of the superiority of the electric in its own special sphere the movement will extend into all the other and numerous applications which lie open to commercial users of vehicles. As mentioned, the electric has a very special field of utility for ambulance work in all great cities, its good qualities of smokelessness, freedom from odours, noise, vibration and fire risk, making it an ideal automobile for conveying the invalid from home to hospital. Another special application of the electric in municipal work is that involved in fire station equipment, particularly when distances are moderate and speeds of not more than 25 m.p.h. are adequate. This type of apparatus is already in use in Berlin, London and New York and has proved conspicuously successful.

The authors agree with Mr. Ayton's opinion that electrics are likely to hold more business potentialities for the central station engineer than even the cooking and heating loads will bring. The discussion of rates is therefore, at this very important moment, eminently timely and necessary. No better talking-point could be put into the mouth of the vehicle selling engineer than that of cheap power. Whilst unanimity of tariffs is desirable from one standpoint—especially between districts that are adjacent, in order to avoid unhelpful competition—yet there are bound to be many plants relatively isolated where the three farthing or penny rate would be impracticable. Mr. Ayton's remarks on American practice are not without point, though perhaps his attitude hereon would apply far less to the electric vehicle than to early electric tramways. The American engineer always appears deficient in the æsthetic sense—using the term very broadly—to the Britisher. Not only are his creations sometimes unbeautiful to look at, but crude in conception. This is probably because he feels impelled to do something definitely very soon after first entering a new field ; hence his early designs are relatively crude to look at, though they may work fairly well. The all-electric garage idea is a good one and commends itself to the authors as being better than attempting the task of co-operating with petrol garages. The woeful inefficiency of the majority of garages would not appeal to the user of electrics who would expect far more care taken of bodywork and a higher level of intelligence and efficiency than is usually met with in many public garages at present. Mr. Ayton is under a misapprehension in thinking that the authors

prefer chain-drive, as the contrary is true. It is merely stated that *at present* the live axle drive is but seldom employed on commercial electrics. It is of course generally admitted that the worm-driven rear axle is as suited to heavy vehicles as to the lighter duties imposed in passenger machines. It is, however, an open question whether the worm may not give way to other forms of transmission for heavy electrics. The authors incline to the view that some type of direct transmission will have a considerable vogue in the near future, as by this means the differential may be easily eliminated and also four-wheel or front-driving becomes a simply effected possibility. It is to be remembered that the central driven rear axle commonly employed on heavy vehicles has evolved to its present admittedly improvable form on account of the necessity of preserving the rotational axis of engine, gear-box and propeller shaft as much as possible in one unbroken straight line. The superior adaptability of the electric drive, however, imposes no such restrictions—and hence the higher transmission efficiency which is so vitally desirable on an electric entails a more straightforward problem in design. Mr. Ayton's plea for a standardisation in motor ratings was quite in accord with the author's views. It would be interesting and useful to discuss this and other questions of standardisation so soon as the proposed Electric Vehicle Association of Great Britain has been formed. Bearings seem to have given no special trouble on American Electrics, though the ball type is used extensively for motor shafts and high-speed work generally. The Timken roller bearing appears to give excellent service for wheel-hubs, and provided this type of bearing be made of first-rate material, it appears to have very great claims for consideration by British designers, its adjustability and line contact making it superior to the relatively non-adjustable ball-bearing.

There is much to be said in favour of Mr. Beauchamp's contention that the heavy type of electric offers the largest immediate scope of employment. Although the lighter machines can be shown to be more economical than either horse or petrol vans, if worked up to a reasonable mileage daily, not to mention their additional features of cleanliness, silence, simplicity and the like. Mr. Beauchamp's conviction that municipalities could find economies by the employment of electrics for shifting heavy loads ought to find much justification in the near future. It is surely not consistent for an electricity department to use petrol vehicles for work that the electric could and would do for a fuel cost of about a quarter as much. The authors wish to

congratulate Mr. Beauchamp on his energetic endeavours and publicity anent the electric. Such efforts should be rewarded with a considerable success, though such enterprises move very slowly in their first stages.

The question of tariffs would be solved best only by admitting that, in cases where current be taken in a garage—whether public or municipal—a further charge should be made over and above the mere price of current. The notion of adding a small increment on to the price of the current in order to pay for standing room, attendance, etc., seems so practical that there is nothing to be reasonably urged against it. In this way the difficulty of making a garage for electrics pay its way would be solved. The suggested penny as a flat rate would be welcomed in many quarters, especially if it were possible to get current cheaper than the penny rate during restricted hours—in the night, for example. The authors do not feel as optimistic as Mr. Chattock appears to feel anent the garage people—notably as to their carrying out this undertaking " for the benefit of the public ! " The usual experience of garages is that such concerns are chiefly noted for inefficiency and rapacity. It would be better in the outset to keep the electric automobile in the hands of electrical men. In time it will pay proprietors of electrical businesses to foster the electric automobile by opening special electric garages for their maintenance. In deciding the awkward question of municipal versus private garages, it is interesting to recount American history. A few very broad-minded station engineers have been known to take first steps to help electrics by opening special garages for their reception and prosecuting an active publicity campaign in their interest. When a load has been built up in this way these stations have persuaded private enterprise to come in and take the garage over, or build a new one. Thus a service of great efficiency was quickly realised on a basis at the same time profitable to the garage owner and adequate from the standpoint of the " electric " owners.

The authors agree with Mr. Sykes' remarks in the main, but think he has overlooked the fact that the sooner a start be made to get electrical men *accustomed* to the idea of electrics, and potentially ready for action, the better for the movement and the quicker will the much-desired increase of load accrue to the stations.

There are great possibilities of the Edison Accumulator being employed extensively for light railway and tramway work. In

the States there are already many installations running with conspicuous success. There are also Edison battery propelled trains on the Cuban Railways and in New Zealand. As an example of heavy duty should be mentioned the Montandon and Mifflinburg tramway near Washington, which operates battery cars on a four-mile line—shortly to be extended to double that length. The route is very hilly, including maximum grades of 12½ per cent., yet some days individual cars run two hundred miles and more and stop for charging *only four minutes at each end of the line*, taking current at *five times normal charging rate*. At night the cars go into their shed with their batteries practically charged, as the short rate boosting proves enough to keep them ahead of the regular running discharge.

The authors cannot help recording their feelings of disappointment that Mr. Crawter referred so slightly to the battery question. His remarks on the early history of electrics in England were exceedingly interesting, and prove that as has often been the case, England was a pioneer in this branch of electrical industry. Mr. Crawter's pessimism, however, does not seem justified in the light of a careful scrutiny of the conditions. Whilst it is true that America has the largest number of petrol cars in the world within its boundaries, as well as the greatest number proportionally to population, it is also true that it has by far the largest number of electric automobiles—this in spite of the fact that American prices of these vehicles are very largely in excess of that of the average price of gasolene machines. Surely, then, in England where there is more wealth than in any other country, the pleasure electric should find a place for itself in the hands of those people who require an extra car for short distance work, or to perform the function of a fast carriage. This latter class includes many doctors and other professional men, as, for example, engineers, surveyors, architects and others whose work entails frequent short journeys totalling in the aggregate anything up to 60 miles per diem. By suitable arrangement an electric can run easily 100 miles in the space of a working day. It is, of course, obvious that the man who wishes to do touring would not choose an electric unless he happened to be an enthusiast who did not mind the present-day inconvenience of recharging. It is quite conceivable that in the course of the next few years the charging facilities will be extensively enough available to make touring by electric a practical possibility. The authors regret that, through a typographical error, they misstated the average life of a traction lead battery. They also wish to record their appreciation of Mr. Crawter's generous criticism of their efforts.

Alderman F. Smith would find some leading information bearing on his query anent heavy vehicles on Table I. For some services there have been made even heavier electrics than the 5-ton machine enumerated. It is very specially for heavy work that the electric is useful. There is no doubt that 7-ton capacity machines running at 5 m.p.h. will have a considerable vogue in the manufacturing districts of Lancashire and other centres of heavy industry.

The suggestion of organising a series of stations at which charged batteries could be taken in exchange for discharged ones is not so feasible as it sounds, unless the recipient of a new battery undertook to drop this one at some allotted station and thus preserve the distribution of batteries in a way which would be kept track of with reasonable simplicity. Obviously some such limitations would be vitally necessary for even the partial success of this scheme, as otherwise the wanderings of, say, 1,000 batteries would only be compared in complexity with the rearrangements of a tray of bicycle balls when shaken haphazard ! At a later stage Mr. Grogan's further views on the tariff question will be helpful, as he has had so much experience in getting cheap units !

Mention is timely of the standard voltage most convenient for battery charging. American practice favours a source giving 110 volts d.c., or, if possible, a range from 110 to 125 volts. The higher voltages permit of rapid boosting being achieved at extra high rates in emergency. There appears to be a volume of evidence in support of adopting 110 as the standard in this country. Two reasons being that in the case of lead batteries this voltage is that employable with the standardized forty-four cell batteries—and that this same pressure suffices to charge an Edison nickel-iron battery of sixty cells at an automatically tapering rate. Doubtless, however, this and other such matters will shortly be discussed by the committee now being formed by the I.M.E.A. to deal with the electric automobile in a really comprehensive manner. The authors welcome the formation of this British Electric Vehicle Association most heartily and would like to point out how powerfully such a body, composed, as doubtless will be the case, of electrical men, manufacturers, battery makers, and others concerned in the industry, can affect progress. The means employed to this end should include every method, technical and otherwise, that can gain useful publicity for the movement. Thus, in the beginning, reliable records of vehicle performance might be compiled so as to be readily avail-

able to the engineer who is looking into the subject *de novo*. For this purpose manufacturers would doubtless assist by loaning equipment—vehicles, etc., to the engineering committee in order that typical tests might be made under practical running conditions, thus enabling the claims made for the electric to be substantiated. Such experiments might be recorded in one of the Electrical Journals from time to time or issued as official publications. Then again the questions of co-operative publicity, standardization, compiling of records and the many involved jobs that must follow can be best dealt with by the governing body. Hence the authors hope that this may be the beginning of an advance in the field of the electric which may culminate in the functions of the present day stations being extended until they become finally charging and lighting stations, the latter being a mere afterthought!

The President's views on the battery clearing-house sound so plausible that the authors feel inclined to delete all they have said to Mr. Grogan. Time, however, may justify the scheme, though even the optimists must admit that the day is remote when such a scheme will be a commercial possibility. Far better will it be to design the battery so that it may be charged up to full capacity in, say, a quarter of an hour. Even under present conditions, it is possible to recharge 65 per cent. of the total capacity of the battery in one hour. May the authors suggest that the President reconsider his charging station for launches, as there appears a very rosy future for this class of work. As the proprietors of the charging station mentioned by the President will doubtless have retired on snug little fortunes made out of 2s. 6d. and 7s. current, the President will be able to exercise his own judgment in this field, and if current at 1d. per unit be available in the near future a brisk business at Mr. Edgcome's charging station may be safely prophesied.

Reliability of the "Total Costs per Unit Sold."

By A. M. Reid,

Chief Accountant, Corporation Electricity Department, Dundee.

In comparing the records of the various electrical undertakings in the tables published in the technical press, one is at once struck with the wide difference in the various costs, and particularly the costs per unit sold.

It has never been quite apparent to me why there should be such a difference, particularly when it is remembered that all items of special expenditure are supposed to be excluded, and only those items common to every undertaking, included in the working costs.

Although no two undertakings sell exactly the same number of units, it does not follow that their costs per unit sold should be so much at variance, as there are really only two items to be considered, namely, the total units sold and the working costs.

Provided there are no exceptional and outstanding circumstances it would therefore appear that the "costs" should at least bear some resemblance, but a study of the figures reveals anything but this.

There can be no dubiety about the units sold, and if all the accounts of the various undertakings were made out on exactly the same lines, and the same methods adopted to show the various items of income and expenditure, it would be an easy matter to show the correct working costs per unit sold. From a perusal of several accounts, however, it is evident that this is not the case.

I might say here that in making the following statements it must not be understood as casting any reflection on the management of the papers concerned, who set forth very clearly practically every item of interest, but rather as drawing attention to the lack of uniformity of the various undertakings in compiling their annual accounts. In the accounts which I have scrutinized I find almost every undertaking has a different method of showing the various items, and in my opinion it is practically impossible, from the accounts at any rate, to state the costs of each correctly.

The following are several of the items, which in some cases are included in the working costs, while in others they are not, it all depending on the manner in which they are stated.

Bad Debts.—In several of the accounts this item is shown deducted along with discounts from the income. In others again it is included in the expenditure, generally under management, and consequently to the detriment of the costs per unit sold.

Interest on Deposits held as Security.—Opinions seem to differ as to which heading this ought to come under, whether it ought to be included in the ordinary revenue or net revenue accounts, or in the latter under interest. I find each of the three methods represented, and of course where it appears in the first-mentioned it is reckoned in the working costs, in which case it affects the gross profit and also the costs per unit sold.

Assessments and Taxes.—The amount paid for income-tax is included in the working costs, whether it be stated in the revenue or net revenue accounts. There are, however, different methods of showing this. In some cases the amount shown as income-tax is the difference between the actual sum paid to the Inland Revenue Authorities and the amounts retained from interest on loans, the amount appearing against the latter being the actual sum payable without deduction of the tax. In other cases again the position is entirely reversed, the actual income-tax paid being shown and interest being credited with the amounts deducted. Obviously those who show this item by the first-mentioned method have a decided advantage over those employing the latter method, so far as their costs per unit sold are concerned. The following are two examples, which are evidently accounted for, to some extent, by the foregoing. The two are not exactly similar, but they are sufficiently near to serve as an illustration.

	£		£
(1) Gross Profit -	64,373	Amount shown as Income-Tax in their Accounts -	2,211
(2) Gross Profit -	49,266	Amount shown as Income-Tax in their Accounts -	8

In the first case it represents .03d. per unit sold, while in the latter case it is nil.

Dealing with the assessments and taxes, it is a debatable point whether for purposes of comparison, these should be included in the working costs at all. In the first place they are wholly outwith the control of the management of any undertaking, although from the records, several appear to be pretty fortunate notwithstanding this. For instance, in some towns they are assessed on the full value of their underground pipes and mains, while others are allowed a reduction on this item on their city rates. To put it more plainly, we will take the valuation of an undertaking at £20,000, and the city rate at 2s. 8d. per £. Certain undertakings get off by paying only a quarter of this rate, namely, 8d. per £, while others have to pay the full rate of 2s. 8d. If we were fortunate enough to be allowed this reduction in Dundee it would reduce our costs by .03d. per unit.

Repairs and Maintenance.—In the majority of cases the whole cost of hiring and wiring is excluded from the working costs and deducted from the income received from same, at least where such expenses are clearly stated in the accounts. In other cases, where the costs of such a scheme are not so clearly stated, they are not deducted but are included in the working costs. I also find an undertaking showing an item in their accounts amounting to fully £3,000 under repairs, maintenance and renewals of transformers, meters, switches, fuses and other apparatus on consumers premises. In every case but this one, the whole cost under this heading appears to be included in the working costs, but the undertaking I refer to, deducts the sum of £767 for expenses in connection with their Hiring and Wiring Department, which they say is included in the first-mentioned sum. I am not inferring that this figure is other than absolutely correct, but why not state it clearly in the accounts. I think it will be admitted that such a system is not conducive to absolute correctness, and if practised to any great extent, might easily be misconstrued. In the case I refer to, the sum deducted is equal to .05d. per unit.

Even although there seems to be an apparent loss in several cases, the same is not included in the working costs. Why should such losses be practically ignored? It means the sale of many more units, and I fail to see why any deficiency incurred in getting this extra business ought not to be debited to the working costs. There is also another side to such a system. If it be generally known that any loss is not to be included, it is left open for items to be allocated against the Sales Department, which, in ordinary circumstances would be allocated elsewhere if such an understanding did not exist. The suggestion may be considered offensive, but none will gainsay that such a thing is possible.

Take the case of a Corporation without hiring and wiring powers, but yet employing canvassers who look after the consumers' interests generally and get as much new business as possible. The expenses of this are considerable, and in Dundee are included in the working costs. If we had a

hiring and wiring scheme, we would get more business, sell more units, and the whole cost of this including canvassing and all work done for consumers, would be deducted off the income and therefore not appear in the working costs. As a matter of fact there seems to be no apparent reason why our expenses in this connection should not be put down as a loss on our Sales Department and deducted from our working costs.

Interest and Special Expenditure Less Credits.—In the first place it is not at all clear why interest should be combined with special expenditure, as they appear to be two distinct headings which ought to be stated quite separately. It is also perfectly evident that all are not taking the same advantage of this heading. Taking the case of Dundee, being the one I am most familiar with, I may say that at no time has anything appeared under this but interest pure and simple. During the years 1905–1909, sums amounting to £31,145 were paid out of revenue for reduction of capital debt, the whole amount allocated to repairs, and included in the working costs. If they had been included under special expenditure our costs per unit would have been reduced during those years by .32d., .5d., .4d., .38d., and .35d. respectively. There is evidently a variety of methods in vogue for showing items of special expenditure, the following four being those which I have met with in the various accounts.

(1) Included in the Ordinary Revenue Account as Special Expenditure.
(2) Included in the Net Revenue Account as Special Expenditure.
(3) Paid out of Depreciation Fund.
(4) Paid out of Renewals Fund.

The particular system adopted of course affects the net profit. In the first two cases where it is included under special expenditure, the net profit is less by such an amount, while in the latter two the net profit is exclusive of any such expenditure. There are sure to be other cases which might be put under special expenditure, but are simply charged to revenue, probably to repairs, very likely because it is not desirable to show them in the accounts, or because, individually, they are hardly worth showing. In our own case

two such examples come to mind which have been included under repairs which might have been allocated to special expenditure.

Repairs and Maintenance of Incandescent Lamps for Stair Lighting.—The cost of this I find is not always dealt with in the same way. We find one undertaking deducting the costs from the income received from such a scheme, while in other cases where the income from such is not shown separately, the expenses are included in the working costs.

Expense of Loans.—There are evidently differences of opinion as to where this item ought to appear in the accounts. In some cases it is included under management, while in others it appears in the net revenue account. Those employing the latter method have again an advantage, in so much as their working costs are relieved of this item, while those who include the same under management do so to the detriment of their costs.

Income other than that from the Sale of Current.—The methods adopted for showing the various sources of income is also very varied. There are cases of sums received from the sale of scrap metal, charging of accumulators, connections to consumers' premises, rent charges on cost of laying mains, etc. being included under income. Such items are shown in the *Electrical Times* under revenue from meter rents and other sources. The other method, and evidently the popular one, seems to be to credit the corresponding accounts in the expenditure, in which case of course it reduces the working costs and consequently the costs per unit sold.

Repairs and maintenance of office furniture and fittings I find in one or two cases included under management, although the common method appears to be to include this under repairs to buildings. In this instance it does not affect the total costs per unit sold, but still benefits the repairs costs at the expense of management costs, and, besides, nullifies the comparison with other undertakings.

There is another point which I would mention, and it affects the working costs very adversely, namely, the cost of the upkeep of overhead equipment. As is well known the price of current for tramway purposes may include four things, viz.: (1) power supply only; (2) power supply and capital charges on generating plant; (3) power supply and capital charges on generating plant and tramway feeders; (4) power supply and capital charges on generating plant and tramway feeders and upkeep of overhead equipment. There are, I believe, six undertakings who supply current for tramway purposes under number four, and there is no doubt they are at a decided disadvantage, in so much as the cost of the upkeep of overhead equipment is included in the working costs. Bearing in mind that the whole cost of trimming and repairing arc lamps is in every case excluded from the costs and deducted off the income received from this source, it seems only fair and equitable that the cost of upkeep of overhead equipment ought to be deducted off the income received from tramway undertakings and excluded from the costs.

If I may be permitted, I would offer the following suggestions which I think would tend towards uniformity, and we will take each of the items which I have already brought before your notice.

Bad Debts.—I would suggest that these be shown in all cases as a deduction from the income for obvious reasons. In the first place this is in accordance with the Board of Trade Form of Accounts, and secondly, although the income actually received is less by this amount, yet the current has been sold and certain expenses have already been incurred in supplying the same. Further, they are not expenses in the true sense of the term, and the working costs should not be saddled with items that really mean loss of revenue.

Interest on Deposits.—I would suggest that this be included under net revenue, as it does not seem to be a fair charge against the working costs. Some undertakings may be so situated in respect that they require practically no

deposits, while others may be compelled to ask deposits to a large extent. Again, in the majority of cases this is dealt with by the Treasurer's Department, which is generally outwith the direct control of the Works Management.

Assessments and Taxes.—With regard to the income tax, equally strong arguments may be put forward for each of the systems presently adopted, but for the sake of uniformity a definite understanding is certainly required. The popular method appears to be to show the net income tax under the working expenses, which system appears to have the strongest claim. As to whether assessments and taxes should be included in the working costs or not, I have already given my reasons why it might possibly be excluded, but would be pleased to hear other opinions.

Repairs and Maintenance.—I have already gone into the question of the hiring and wiring expenses at some length. At present there seems to be some slight confusion between the Hiring and Wiring and Sales Departments. My own idea is to show the whole results of both under an account entirely separate from the ordinary income and expenditure. The balance would be transferred to the latter, and if it should be a loss it certainly ought to be included in the working costs.

Interest and Special Expenditure.—I cannot see anything in favour of combining interest and special expenditure. Owing to the various methods adopted, which I have already explained, the principle to follow would appear to be to show the net profit exclusive of any special expenditure. Other headings might follow showing how the profit has been appropriated, one of which might be "special expenditure." If it could be arranged the amounts set aside for reserve, renewals, depreciation, and relief of rates, would be other useful headings.

Repairs and Maintenance of Lamps for Stair Lighting and Upkeep of Overhead Equipment.—If it is correct to exclude the cost of repairing and trimming arc lamps

from the working costs and deduct from the income, I fail to see why the same procedure should not be adopted with repairs and maintenance of stair lighting and overhead equipment.

Expenses of Loans.—As this has really a connection with interest and sinking fund, it would appear that the proper place to show the same is under net revenue.

Income other than that from Sale of Current.—There must be different opinions as to whether certain items should appear under income or be credited to the proper allocation in the expenditure. Is it not advisable to include under income only the sale of current and meter rents, and credit the costs with all other items ? It would certainly tend to uniformity. If other items are to be included under income it seems to me that difficulties must at once crop up in deciding which are, and which are not to be included, especially when the items are so numerous. Income from the sale of current is of a steady and reliable nature, whereas other income as mentioned above must be more or less fluctuating in its nature and vary from year to year.

It may be argued that in a few cases, even if the adjustments I have recommended were made, it would not affect the costs per unit sold, and whether a sum is paid out of revenue or net revenue does not make any difference to the financial condition of any undertaking. This is quite true, but it has to be borne in mind that besides affecting the costs per unit sold in other cases, it affects the headings, income, gross profit in each case and occasionally the net profit.

Let us look for a little at the question from another standpoint.

Taking it for granted that the accounts of each undertaking are made out on a uniform basis and the figures published including the same items in every case, would the costs per unit sold even then be of more than passing interest ?

The management of any undertaking must admit that if a systematic campaign were instituted to reduce the costs, this could be accomplished by various means, which would, however, probably reflect on the financial condition of the concern. Several methods come to my mind by which this could be done, but I will content myself by quoting the following two.

Take first the stores system. Unless there is a proper stores system (and even with this) there is bound to be some guess work in allocating material, although with a correct and workable system this is very much reduced. In booking out stores (we will suppose no stores are issued without a stores order signed by the assistant in charge), we will take the case of an employee who is sent to do a repair job. He requires material and gets an order for certain articles. Now, it is within the bounds of possibility that only half the material he has taken out of stores has been used on this job. He may take the remainder and book it back, in which case the proper allocation would be credited, but more than likely he will keep the material and use it on his next job, which may be an allocation against capital. If there was much of this it would affect the costs per unit sold, but on the other hand, the beneficial effect on the financial stability of the undertaking is considerable.

Another point is the carting of stores. In Dundee we employ our own carters, and all carting of any stores, unless for a specified job which can be debited correctly at the time, is allocated to expenditure. The stores may eventually be used on capital work, but in all cases of uncertainty such as this, the above system has been adhered to.

These are two points, but more than likely they can be added to by others present, and I think they serve to show that the important point is rather whether a concern is sound financially than having low costs per unit, although I admit that where the two are combined no objection can be taken. If one wished to invest money in an electrical undertaking, I think the first point he would look closely

into would be the financial condition and the possibility of getting a good return for his money, and if a business only showed moderate profits, even although the costs per unit were of the lowest, there would be no attraction.

Viewed from this standpoint, my opinion is that more attention and certainly more credit is due to the management of an undertaking, which, although only showing moderate costs, is yet financially strong.

If the particulars of each undertaking must be published and are to be of any value for comparison purposes, which with all deference I submit they are not at present, there is no doubt that something should be done to get all accounts made out on a uniform basis. So long as the present diverse methods exist, so long will these inexactitudes remain. If for no other reason than to show the technical Press that their efforts in publishing the records in so much detail is appreciated and also to minimise the work of analysing each, the matter should be looked into at once.

Incorporated Municipal Electrical Association.

FRIDAY, JUNE 20th.

MEETING AT THE INSTITUTION OF ELECTRICAL ENGINEERS.

Annual General Meeting.

ELECTION OF PRESIDENT AND PLACE OF MEETING FOR 1913–14.

On the motion of the PRESIDENT (Mr. J. E. EDGCOME), seconded by ALDERMAN R. C. DAVIS (Chester), MR. R. A. CHATTOCK, Senior Vice-President (Chief Electrical Engineer, Birmingham), was unanimously elected President for 1913–14.

Mr. Chattock, in thanking the members for the honour they had conferred upon him, said that it would give his friends in Birmingham, and the Electricity Committee, the greatest pleasure to receive the Association there for their next Convention if they would accept an invitation to hold the Meeting there.

Alderman J. P. Smith (Barrow-in-Furness) moved that the next Convention be held in Birmingham. This was seconded by Mr. H. FARADAY PROCTOR and carried unanimously.

ELECTION OF VICE-PRESIDENTS.

MR. H. RICHARDSON, Junior Vice-President (Chief Electrical Engineer, Dundee), was elected Senior Vice-President, and MR. A. C. CRAMB (Chief Electrical Engineer, Croydon), Junior Vice-President. There were no other nominations.

ELECTION OF MEMBERS OF COUNCIL.

According to the Articles of Association, the following Engineer Members of Council retired : F. AYTON (Ipswich) ; A. C. CRAMB (Croydon) ; F. M. LONG (Norwich) ; T. ROLES (Bradford).

The following were the nominations for these four vacancies :—

W. Wyld,	Hampstead.	S. E. Fedden,	Sheffield.
H. R. Burnett,	Barrow-in-Furness	A. H. Shaw,	Ilford.
E. E. Hoadley,	Maidstone.	T. Roles,	Bradford.
H. W. Bowden,	Poplar.	C. S. Davidson,	Barnes.
W. C. Pickvance,	Wrexham.	F. Ayton,	Ipswich.
A. S. Barnard,	Walsall.		

As the result of the ballot, the following were elected :—

S. E. Fedden, Sheffield.	T. Roles, Bradford.
F. Ayton, Ipswich.	W. Wyld, Hampstead.

The following Chairmen Members retired from the Council under the rules : ALDERMAN CROWTHER (Sheffield) ; ALDERMAN SINCLAIR (Swansea) ; BAILIE WILLOCK (Glasgow) ; and for the three vacancies the following were the nominations :—

Alderman Littler, West Ham.	Alderman Sinclair, Swansea.
Bailie Willock, Glasgow.	Councillor Ellaway, Birmingham.
Alderman Barge, Poplar.	Alderman Crowther, Sheffield.

The following were elected by ballot :—

Councillor Ellaway, Birmingham. Bailie Willock, Glasgow.
Alderman Sinclair, Swansea.

The Honorary Officials were re-elected as follows : Hon. Solicitor, ALDERMAN PEARSON (Bristol) ; Hon. Treasurer, J. E. EDGCOME (Kingston) ; Hon. Secretary, H. FARADAY PROCTOR (Bristol).

COUNCIL'S REPORT.

The Eighteenth Annual Report of the Council having been previously circulated, was taken as read.

Incorporated Municipal Electrical Association.

EIGHTEENTH ANNUAL REPORT OF THE COUNCIL,

From June, 1912, to June, 1913.

(*To be submitted to the Annual General Meeting at London, on Friday, June 20th,* 1913.)

THE membership of the Association now stands at 386, made up as follows :—

Committees (Members)	167
Chief Electrical Engineers (Members)	177
Honorary Members	5
Chief Assistants (Associate Members)	5
Assistants (Associates)	32
	386

After allowing for deaths, resignations, removals, and lapses due to members leaving Municipal employ, there is an increase of six on last year's total.

Since the publication of the last Annual Report, the Council have held nine meetings. At their first meeting they appointed the following Standing Committees, who subsequently elected their chairmen as stated.

PARLIAMENTARY.—C. E. C. Shawfield, R. A. Chattock, H. Richardson, Alderman Pearson, H. Faraday Proctor, J. E. Edgcome, A. C. Cramb, Alderman J. P. Smith, Councillor Crowther.

FINANCE AND GENERAL PURPOSES.—C. E. C. Shawfield (Chairman), R. A. Chattock, H. Richardson, Alderman Pearson, H. Faraday Proctor, J. E. Edgcome, A. C. Cramb, W. W. Lackie, C. Furness. F. M. Long, J. Christie, S. J. Watson, Alderman Sinclair, T. Roles,

EDITING.—C. E. C. Shawfield, G. Wilkinson, H. Richardson, F. M. Long (Chairman), S. J. Watson, S. L. Pearce.

The Council meetings this session have been held in London with the exception of two, one of which was held at Wolverhampton in March and the other at Kingston-upon-Thames in May. The attendances are set out below. There have also been a number of meetings of Standing and Special Committees and Sub-Committees appointed to deal with specific matters. These Committees have met and reported to the Council periodically on the matters referred to them.

By the courtesy of the Council of the Institution of Electrical Engineers, the Council and Committee meetings in London have been held at the Institution's headquarters.

The attendances of members of Council are set out in the following schedule :

	1912.				1913.						
	June, Harrogate.	July, London.	October, London.	November, London.	January, London.	February, London.	March, Wolverhampton.	April, London.	May, Kingston.	Maximum possible.	Actual.
Ayton, F., Ipswich - -	×	—	×	×	—	×	—	×	×	9	6
Bruce, Alderman, Sunderland - -		—	×	×	×	×	—	×	—	9	4
Christie, J., Brighton - -	×	×	×	×	×	×	×	×	—	9	8
Cramb, A. C., Croydon - -	×	—	×	×		×	×	×	×	9	8
Chattock, R. A., Birmingham - -	—	—	×	×		×	×	×	×	9	7
Crowther, Councillor, Sheffield - -	×	—	—	×	×	×	×	×	×	9	8
Edgcome, J. E., Kingston-upon-Thames	×	—	×	—	×	×	×	×	×	9	7
Furness, C., Blackpool - -	×	×	×	—	×	—	—	×	—	9	5
German, Councillor, Brighton - -	—	Time	expired.							1	—
Gibson, Councillor, Wolverhampton - -		—	×	×	—	—	×	—	×	8	4
Lackie, W. W., Glasgow - -	×	—	×	—	—	—	×	—	×	9	3
Long, F. M., Norwich - -	×	×	—	×	×	×	—	×	—	9	7
Pearce, S. L., Manchester - -	×	—	—	×	×	×	×	×	—	9	4
Pearson, Alderman G., Bristol - -	×	×	×	×	×	×	×	—	×	9	7
Proctor, H. Faraday, Bristol - -	×	×	×	×	×	×	×	×	×	9	8
Richardson, H., Dundee - -	×	×	×	—	×	×	×	×	×	9	6
Roles, T., Bradford - -		×	×	—	—	×	×	×	×	8	6
Rowntree, Councillor, Harrogate - -	—	Time	expired.							1	—
Seabrook, A. H., London - -	×	×	×	×	×	×	—	×	—	9	7
Shawfield, C. E. C., Wolverhampton - -	×	×	×	×	×	×	×	resigned.		7	6
Sinclair, Alderman, Swansea - -		—	×	×	×	×	×	×	—	8	4
Smith, Alderman, J.P., Barrow - -		—	×	×	×	×	×	—	×	8	6
West, Alderman, Coventry - -	×	Time	expired.							1	1
Wilkinson, G., Harrogate - -	×	×		—	×	—	—	×	×	9	6
Watson, S. J., Bury - -	×	×	×	×	×	—	—	×	—	9	6
Willock, Bailie, Glasgow - -	×	—	—	—	—	—	—	—	×	9	2
Wyld, W., Birkenhead - -	×	Time	expired.							1	1

Information Bureau.

Your Council have given further consideration to the proposal that a statistical bureau should be established by the Association and are of opinion that the Association would not be justified at present in incurring this expense which would be entailed in carrying out the suggestions of those members who have interested themselves in the proposal. There is not sufficient evidence before your Council that such a bureau would be adequately supported or be of any very material benefit to the members, and they consider that the present system of filing information with the Secretary would meet all reasonable requirements if members made a point of forwarding information likely to be of general use.

Your Council is frequently called upon by members for advice on points arising in their business, and during the past year they have been able to express their views on various matters such as liability for accidental damage, the action of Gas Companies in seeking powers to supply electricity, and on various other subjects brought to their notice.

Editing Committee's Report.

The Committee have been so fortunate as to secure this year the co-operation of Dr. S. Z. de Ferranti, who very kindly consented to read a paper at the Convention on "Prime Movers." The complete list of papers is as follows :

"Prime Movers," by Dr. S. Z. de Ferranti, Past-President I.E.E.

"Air Filtration," by Mr. J. Christie, Past President, Chief Electrical Engineer, Brighton.

"Electric Vehicles," by Messrs. W. H. L. Watson and Raymond J. Mitchell. Introduced by Mr. A. H. Seabrook, Member of Council, Chief Electrical Engineer, Marylebone.

"Reliability of the Total Costs per Unit Sold," by Mr. A. M. Reid, Chief Accountant, Dundee Corporation.

Mr. Reid has very kindly agreed that his paper shall take the form of a contribution to the proceedings, in the event of it being impossible to have it discussed during the Convention.

The suggestion in the last Report that copies of the Proceedings should be supplied in bulk at reduced rates to Electricity Committees has been adopted and has met with considerable support. A large number of additional copies were applied for and supplied, and similar facilities will be extended to Committees for the future.

This year the papers and discussions are, for the first time, to be printed in the first person.

Discussions "in Camera."

At the express wish of the members, arrangements have been made for one morning to be set aside for a meeting *in camera*.

A number of suggestions for subject have been received, and it is proposed to give the members an opportunity of expressing their views on the following subjects among others :—(1) The I.M.E.A. Bill. (2) Heating and cooking.

Electrical Exhibit.

A new feature at this year's Convention will be an exhibit of electric heating and cooking appliances.

It is to be regretted that there were again no entries for the Travelling Studentship. Your Council feel that the Associates lose much of educational value by neglecting this opportunity of extending their experience and knowledge.

Finance Committee's Report.

The revenue account shows that the sundry expenses were heavier than last year, but the difference is practically accounted for by a donation to the building fund of the Institution of Electrical Engineers, and an honorarium to the Hon. Secretary's clerical staff. The other outgoings are normal, and there is a surplus for the year of £58 as against £20 last year.

There is a slight falling off in the income from subscriptions due to fluctuations in the membership, but there is a very considerable increase in the income from "proceedings," and the Convention shows a profit.

The liabilities have decreased, and there is a total surplus of assets of £721. The outstanding subscriptions are only £25, part of which has since been received. The invested funds have been increased by £100 and now stand at £600 at cost, and there is a cash balance of £116.

Change of President.

Some months ago your Council received with much regret an intimation from the President, Mr. C. E. C. Shawfield, that having accepted an appointment involving his giving up municipal employment at the end of March, he had no option but to tender his resignation as President, on his membership lapsing under the regulations. Your Council could not, under the circumstances, do otherwise than accept the resignation, and in doing so they placed on record their appreciation of Mr. Shawfield's long and valuable services to the Association, an action which they know the members will wish to endorse.

To fill the vacancy for the remainder of the year of office, your Council felt that the proper course was to invite a Past President to take the office, leaving it to the members to appoint their own President at the next Annual Meeting in the usual way rather than anticipate their selection in

INCORPORATED MUNICIPAL

INCOME and EXPENDITURE ACCOUNT

The Bold Figures are for the twelve

1912. £	s.	d.	EXPENDITURE.	£	s.	d.	1913. £	s.	d.
			To Bad Debts—						
14	19	0	Subscriptions written off ...	...		...	37	2	0
			,, General Expenses—						
10	0	0	Reporting and Clerical Assistance	12	0	0			
0	10	6	Bank Charges	0	17	4			
4	4	0	Audit Fee	4	4	0			
39	3	7	Sundry Expenses	60	2	10			
53	18	1					77	4	2
37	1	10	,, Postages	...		...	34	12	9
159	9	8	,, Printing and Stationery ...	...		...	156	13	5
150	0	0	,, Secretary's Salary	...		...	150	0	0
348	5	3	,, Convention Expenses ..	...		...	312	6	11
20	5	3	,, Commission	...		...	19	0	3
12	3	0	,, Travelling Studentship ...	...		...	–	–	–
20	8	3	,, Surplus	...		...	58	6	4
£816	10	4					£845	5	10

BALANCE SHEET as

1912. £	s.	d.	LIABILITIES.	£	s.	d.	1913. £	s.	d.
32	16	0	To Subscriptions paid in advance	...		...	25	14	0
18	3	2	,, Sundry Creditors	...		...	12	4	1
			,, Surplus—						
642	6	2	Balance, April 1st, 1912	662	14	5			
20	8	3	Plus Surplus, for year 1912-13 ...	58	6	4			
662	14	5					721	0	9
£713	13	7					£758	18	10

Report of the Auditors, to the Members of the Incorporated Municipal

We have audited the above Balance Sheet, dated 31st March, and our opinion it is properly drawn up so as to exhibit a true and correct view of and the explanations given us, and as shown by the books of the Association.

140, Leadenhall Street, London, E.C. 17th April, 1913.

ELECTRICAL ASSOCIATION.

for the year ended 31st March, 1913.

months ended 31st March, 1912.

1912. £	s.	d.	INCOME.	£	s.	d.	1913. £	s.	d.
			By Annual Subscriptions—						
170	2	0	Committees	174	6	0			
192	3	0	Members	185	17	0			
8	8	0	Associate Members	5	5	0			
9	15	0	Associates	7	15	0			
380	8	0					373	3	0
13	3	10	„ Dividends and Interest				17	6	2
			„ "Proceedings"—						
92	3	0	Sales and Advertisements				116	13	2
330	15	6	„ Convention Receipts...				338	3	6
£816	10	4					£845	5	10

at 31st March, 1913.

1912. £	s.	d.	ASSETS.	£	s.	d.	1913. £	s.	d.
			By Sundry Debtors—						
6	6	0	Committees	1	1	0			
48	6	0	Members	18	18	0			
8	8	0	Associate Members	-	-	-			
6	10	0	Associates	1	5	0			
3	5	6	Sundry	3	15	0			
72	15	6		24	19	0			
15	0	0	Less Reserve for Bad Debts ..	15	0	0			
57	15	6					9	19	0
16	3	11	„ Parliamentary Expenses				33	5	0
			„ Investment *at cost*—						
501	17	0	£600 L.C.C. 3½ % Stock				502	5	0
			„ Cash—						
136	13	8	At Bank	116	9	10			
1	3	6	In Hand	-	-	-			
137	17	2					116	9	10
£713	13	7					£758	18	10

Electrical Association.
have obtained all the information and explanations we have required. In the state of the Association's affairs, according to the best of our information

BOLTON, PITT & BREDEN, *Auditors*
J. E. EDGCOME, *Hon. Treasurer.*

any way. The choice of your Council fell upon Mr. J. E. Edgcome, Past President and Hon. Treasurer, who, after due consideration, most kindly consented to fall in with the wishes of the Council, who feel that the thanks of the Association are due to Mr. Edgcome for undertaking the onerous duties at very short notice and under unusual circumstances.

Testing of Materials.

In the last Annual Report attention was drawn to the apparent lack of reasonable facilities for the testing and certification of materials used in the electrical industry, and to the steps taken by your Council to approach the National Physical Laboratory and the I.E.E. with a view to their co-operation.

After further consideration your Council felt that the matter was one which could be dealt with more effectively by the I.E.E., if they would consent to do so, and it was accordingly left to them to continue their investigations.

Electric Supply Publicity Committee.

Your Council were approached by the Committee with a view to getting some of the larger municipalities to financially support a scheme for an extension of the Committee's proposals on a large scale. The difficulty was and is that many local authorities are at present debarred from spending money on publicity and other similar objects, and until the I.M.E.A. Bill is passed, the electrical industry will continue to be hampered and to be unable to compete with other industries in regard to developing its resources.

Rating of Metal Filament Lamps.

Your Council has, through their representatives on the Lamp Standards Committee, been kept in close touch with developments, and some time ago expressed the view that metal filament lamps should be marked with both candle-power and wattage.

Eventually, however, it became clear that there was a growing disposition on the part of makers and central station engineers in favour of rating in watts in place of candle-power, and after further inquiry, your Council had reason to modify their previous view and to express themselves in favour of rating in watts.

Supply of Electrical Energy Conditions.

Your Council being of opinion that these conditions needed revision and amendment have withdrawn them from publication, and have appointed a Sub-Committee to report upon the matter.

Parliamentary Committee's Report.

Electric Lighting Bill.—The Bill promoted by the Association was down for second reading in the House of Commons on June 10th, 1912, but was not reached. Endeavours were made immediately after the last Convention to get the municipalities who are members of the Association to influence their Parliamentary representatives to ballot for a place for the Bill, and the Association as a body, communicated with every member of the House of Commons to the same effect.

So far as your Council are concerned everything that could be done to expedite matters has been done, but the municipalities interested, who, through their representatives, urge the Council at every Annual Meeting to press on with the matter, have with very few exceptions indeed, failed to secure effective services in response to the Council's request for their active co-operation. The chances of the ballot were thereby so restricted as to render any progress extremely problematical, and those members of Parliament who had agreed to ballot, and who, in one case at least, attended at great personal inconvenience, drew such places as entirely extinguished any chance of the Bill being reached

this Session. In the meantime much spade work has been, and is being done by your Council, both in conjunction with the Industrial Committee of the Institution of Electrical Engineers, and in consultation with other interested bodies in regard to amending the Bill where necessary without abrogating the principle agreed upon at the last Annual General Meeting.

Although no progress has been made in Parliament this session, a very great deal has been accomplished in reconciling the interests of all who will be affected by the measure, and this being so, there is every reason to hope that in the next session of Parliament it will be made evident that the one object of the Bill is to increase the output and diminish the cost of electricity, and to promote the general welfare of the electrical industry for the benefit of the community generally, in which efforts every section of the electrical industry is concerned.

Sheffield Bill.—Your Council, at the request of the Sheffield Corporation, circularised the members of the Association last December asking them to endeavour to get their respective Parliamentary representatives to support Clause 83 of that Bill, referring to the supply of electric fittings by the Corporation.

Conditions of Contract.—Your Council have under consideration the standardisation of conditions of contract with a view to agreeing upon a document which will be acceptable as a basis for such conditions between the purchaser and the contractor. A joint meeting of representatives of the British Electrical and Allied Manufactures Association and your Association has been held, and the negotiations are still proceeding.

In the meantime your Council has found it necessary to notify the members that the proposed conditions have not yet been agreed so far as your Association is concerned.

Among other matters which have been the subject of negotiation between the two bodies are the following:—

Meter Loans.—Your Council were asked to approach the Local Government Board with a view of getting the term extended to ten or fifteen years. Your Council, however, felt that it would not be wise to ask for more than five years, as in their opinion the purchasing of cheap meters is not due to the short loan repayment periods granted by the Local Government Board, but to the too common practice of municipalities accepting the lowest tender irrespective of other considerations.

Publication of Tenders.—The question of the publication of prices of municipal tenders in the technical Journals has been considered, and your Council expressed their view by inviting the members not to publish lists of tenders. The members with one or two exceptions agreed with the action of your Council.

The question of the organising of exhibitions and demonstrations has also received preliminary consideration by the Associations jointly.

Census of Production.—At the invitation of the Board of Trade, your Council considered the proposed census of production form and made certain suggestions for its modification and for the revision of the schedule relating to the generation of electricity. Your Council's recommendations on these points were subsequently substantially adopted by the Board of Trade.

Representation at Conferences, etc.—Your Association was represented at the Conference of the Municipal Tramways Association in London in September last, by Mr. C. E. C. Shawfield, President, and Mr. A. C. Cramb, Member of Council.

On the invitation of the Council of the Institution of Electrical Engineers Mr. H. Faraday Proctor was appointed by your Council to represent the Association on the Industrial Committee, of which body, another member of your Council, Mr. A. H. Seabrook is Vice-Chairman.

On the invitation of the Council of the British Electrical and Allied Manufactures Association your Council appointed Messrs. H. Faraday Proctor, Hon. Secretary, A. H. Seabrook, Member of Council, and S. L. Pearce, Past President, to represent them on a Joint Committee of representatives of Manufacturers and Engineers (Municipal and Company).

Messrs. G. Wilkinson, Past President, and J. E. Edgcome, Past President and Hon. Treasurer, have been nominated to represent the Association on the Council of the National Association of Local Government Officers.

Mr. A. H. Seabrook represents your Council on the Conference of International Electrical Standardization (Engineering Standards Committee).

Joint Conventions.—At the wish of the Institution of Electrical Engineers the feeling of the Council of your Association regarding closer relationship between the two bodies and the holding of Annual Joint Conferences in place of the I.M.E.A. Annual Conventions was ascertained. The result of a communication to members of your Council was that the majority were averse to the proposal in principle though several saw no objection to an occasional joint conference. The opinion was expressed that the interests of the two bodies were entirely different and distinctly opposed in some instances. After due consideration it was agreed that while there was a general feeling in favour of co-operation under special circumstances, your Council did not consider it to be feasible to hold joint Conventions.

Constitution of the Council.

Your Council have given very careful consideration to the wishes of the members as expressed at the last Annual General Meeting, and after long and careful enquiry and consideration the consensus of opinion was to the effect that some alteration of the constitution of the Council was advisable, that the representation of the Association upon the Council should not be upon a proportionate basis; that a change was desirable in the present method of election of the Council; and that the Institution of Electrical Engineers' method of nomination and election should be adopted subject to certain modifications.

In arriving at these conclusions your Council carefully considered the feeling of the members of the Association generally as indicated by the discussion which took place at the last Annual General Meeting, and they are unanimously of the opinion that the wishes of all parties will be adequately met if a scheme could be evolved whereby provision should be made for a continuous influx of fresh blood into the Council, whilst at the same time securing thereon a preponderance of members who will be possessed of that experience which can only be gained by continuity of service. At the same time your Council are strongly of the opinion that the existing constitution of the Council has given on the whole very satisfactory results, and should, therefore, be tampered with as little as possible, and that the desired results can be effected more satisfactorily by a slight alteration in the rules governing the method of election rather than by any drastic alteration in the rules determining the actual constitution of the Council as a body. Your Council consider that a principle should be established that retiring members of the Council shall not be eligible for re-election for a period of twelve months. The effect of this will be that a much larger percentage of new members will be added to the Executive Council annually.

In order to prevent too drastic a change in the *personnel* of the Council at any one election, your Council consider it

desirable that an alteration should be made in the number of vacancies occurring annually, and to extend the period for which a member is elected to serve, to three years instead of two years as at present.

They accordingly recommend that the number of ordinary members of the Council be increased from fourteen to fifteen by the addition of one engineer member, and that one-third of the ordinary members of the Council, that is, three engineer members and two municipal representatives, shall retire annually. They also recommend that the retiring Past President shall not be eligible for re-election as an ordinary member of the Council until after the expiration of one year.

Your Council consider that the method suggested of nomination and election will, with certain modifications, be suitable for adoption by the Association. They accordingly recommend that the method of election of the members of your Executive Council be revised in accordance with the foregoing suggestions, and submit to the members their recommendations for the necessary alterations to the Articles of Association (*see* separate document).

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION.

SPECIMEN BALLOT SHEET FOR OFFICERS AND MEMBERS OF COUNCIL UNDER THE PROPOSED NEW ARTICLES OF ASSOCIATION.

The requisite number of Names must be left on this Sheet.
All other Names to be Cancelled.

Office.	Number of Names to be Left. *	Name.	Local Authority Represented
President	1		
Senior Vice-President	1		
Junior Vice-President	1		
Hon. Treasurer	1		
Hon. Solicitor	1		
Hon. Secretary	1		
Members of Council	Continue in Office	A. Smith	Crewkerne.
		F. Radley	Cunmor
		R. Etherington	Penrith.
		J. Johnson	Breadsall.
		M. Jones	Stanwix.
		A. N. Other	Newtown
Engineer Members	Leave 3 Names		
Committee Representatives	Continue in Office.	Coun. Brown	Crewkerne.
		Ald. Jackson	Elton.
		Coun. Darley	Methill.
		Ald. Knott	Southton.
	Leave 2 Names		

* *N.B.*—The number of names left on this Ballot Sheet must NOT EXCEED OR BE LESS than the number required for the several offices respectively, or the Ballot Sheet will be rendered VOID.

DISCUSSION.

Information Bureau.

A Member asked whether it was the intention of the Council to drop the Information Bureau, or whether there was any chance in the future of it being taken up again. The answering of questions from various engineers was getting increasingly difficult, and only the other day he had sixteen questions to answer which if he had conscientiously endeavoured to do, would have taken him all the morning.

Honorary Secretary said that the only difficulty in connection with this matter was that of expense. To carry out the work properly it would naturally incur the Association in an expense which they could not at the present time afford. It would mean having a paid technical officer to carry out the duties and personally he thought they would have to wait until they got the I.M.E.A. Bill through, when perhaps municipalities might be in a position to subscribe on some different basis than a mere annual subscription of a guinea.

Change of President, 1912–13.

Mr. S. J. Watson (Chief Electrical Engineer, Bury) called attention to the fact that this Annual Meeting was the only occasion on which, as an Association, they had an opportunity of expressing altogether their appreciation of the service which Mr. Shawfield had rendered. This appreciation had already been tendered by the Council, but he should like to move :

> "That the best thanks of the Association be accorded to Mr. Shawfield for the services he has rendered in the past, and the members regret that he has had to sever his connection with this Association."

Mr. R. A. Chattock in seconding, said that Mr. Shawfield's work on the Council for a number of years had been most valuable.

The resolution having been supported by another member,

The President said it had been most unfortunate that Mr. Shawfield had left municipal employ, but he would suggest that they had the machinery to bring him back again. The Association could, elect old members who had done good work for the Association as Honorary Members, so that when they had left municipal employ and could not be active members, they could come back as Honorary Members. They could elect one such member a year, and he did not even suggest that they should necessarily do that, although they had the power. Personally he thought they should look upon that as an honour, which should be very jealously guarded and not given to a man simply because he had held some position in the Association, or had done some work, but should give it to men such as their present Honorary Members, Mr. Wordingham, Mr. Snell and Mr. Rider, men who had done very good work indeed for the Association. Mr. Shawfield had done good work for the Association, and had he remained as President would have done a great deal more. It was a very great misfortune that he was not able to continue in the Council, and the best expression of the manner in which the members appreciated Mr. Shawfield's services would be to elect him as an Honorary Member, and he therefore proposed that Mr. Shawfield be elected as Honorary Member of the Association.

Mr. J. Christie seconded.

Mr. H. Faraday Proctor supported the proposal, and it was carried unanimously.

Electric Supply Publicity Committee.

Mr. W. C. P. Tapper (Stepney) did not think the paragraph under this heading should be passed over without some comment. It was a most important matter to the industry, and it seemed to him that it emphasised the importance of the I.M.E.A. Bill, which would enable various undertakings to subscribe towards publicity. The London Publicity Committee was composed of companies and local authorities, but as the latter could not contribute they were obliged to withdraw, and the Committee was more or less dead at the present moment. It was very important for the Association's members to be able to subscribe

to such funds, and he should like to suggest that something might be done, even before the I.M.E.A. Bill was obtained. The Commercial Gas Association was obtaining subscriptions from local authorities, and they were spending very large sums of money on publicity. Could not something be done in this direction in a preliminary way before the I.M.E.A. Bill was obtained.

Councillor Crowther said that in the past he believed the only objection that had been made to publicity was that municipalities advertised in their own areas, and in that way came into conflict with contractors, but if all the undertakings combined to advertise in a general way simply with the idea of supporting publicity of electricity not in any particular area, he did not think there would be much opposition. There had been opposition which had been manifested in certain municipal areas in past years. The Gas companies did combine together, and they advertised very largely all over the kingdom with the idea of pushing the sale of gas, and if the municipal electrical undertakings followed on the same lines, it would be a very great service.

Mr. A. C. Cramb said that as a former Vice-President of the Publicity Committee, he had given this matter a considerable amount of thought, and he had come to the conclusion that until they got the I.M.E.A. Bill it was quite impossible to talk publicity, let alone do any. The stumbling-block at the present time was the Local Government Board auditors.

The Honorary Solicitor (ALDERMAN PEARSON) said the position was that local authorities who were not subject to Local Government Board audit, could take liberties which others found some difficulty in doing. Possibly it would be wise if a few of the large authorities who were not subject to Local Government Board audit, started a general advertising scheme as suggested by Alderman Crowther. He did not think they need trouble their heads about conciliating their gas friends in opposition, because no matter what they did, electrical engineers would have to assume that electricity had to fight gas, and they must fight it in the best possible way. Therefore he advised local authorities to take the view that they had to

support their own undertakings, and he really did not think that they would run any very material risk in subscribing to funds for advertising. If they were subject to Local Government Board audit, then they were subject to Local Government Board surcharges; but his experience in this was that they could do what they pleased. They could do as they pleased for once; they could make as many mistakes as they pleased for once; and they could apologise and would be forgiven, but they must not repeat their mistakes, because if they did they would be surcharged. Therefore, when they were not subject to Local Government Board audit, they could subscribe, but if they were, they ran the risk of having their rates upset for illegal payments.

Mr. A. H. Shaw said he was subject to Local Government Board audit, but had never had any trouble with regard to publicity matter; so long as he could show something for what they had paid out the auditor was quite content.

Representation at Conferences.

Mr. A. H. Shaw said that since the last meeting there had been a Local Government Officers' Association Meeting upon which the I.M.E.A. was represented, and he asked whether it would be possible in future annual reports of the Council for their delegates to give a short printed report of what had been done by the National Association of Local Government Officers during the year. Many of the members of the I.M.E.A. did not know much about the N.A.L.G.O., and such a report might keep them informed on matters.

The President said that he was one of the delegates to the N.A.L.G.O., but unfortunately since he was appointed there had been one meeting which, through illness he was unable to attend. There was another meeting at Birmingham on the following day (June 21st), at which it was equally impossible for him to attend, so that although their representative he had not been able to attend a meeting of the N.A.L.G.O.

Mr. G. Wilkinson (Harrogate) said he was the other delegate, but was very much in the same position as the President. He

attended the meeting at Leamington two years ago, when Mr. Shaw was present as representing London interests, but had not been able to attend since, and there was nothing to report. The real reason why the I.M.E.A. joined the N.A.L.G.O. was on the question of superannuation. This had, however, been hanging fire, and nothing further had been done since Leamington; but when there was anything to report the I.M.E.A. would hear about it.

Mr. S. J. Watson said that the superannuation bill of the N.A.L.G.O. was a very important matter to Local Government officers. The I.M.E.A. was affiliated with the Association, and last week received draft copies of a new bill. He only mentioned this to show that the N.A.L.G.O. was evidently trying to get on with the thing which had been standing still for so long.

There was no further discussion on the Council's Annual Report, and it was then put to the meeting and adopted.

On the motion of Mr. F. Ayton, seconded by Mr. R. A. Chattock, the balance sheet for the year to March 31st, 1913, was adopted.

Other Business.

Mr. C. Turnbull (Tynemouth) hoped that there should be another discussion in camera next year, and suggested heating and cooking, which had been crowded out this year on account of the discussion on the I.M.E.A. Bill.

A Delegate supported this suggestion.

Mr. S. E. Fedden asked if it was proposed to have another exhibition of electrical cooking apparatus at the next Convention, as there should be a number of improvements during the year.

Mr. H. R. Burnett asked the Council to seriously consider the question of protecting the material interests of their members and more particularly the assistants in central stations. They

had only to look at the newspapers any week to see that the salaries paid to central station engineers and their assistants were an absolute disgrace to the Association. The Association was in a unique position with regard to this matter, inasmuch as they had Chairmen Members and could bring pressure to bear on them, and it would be to the interest of the Association if the Council would take up this matter both as regards salaries, and the conditions of service.

The President said that a cooking exhibition next year would be one of the matters which the Council would consider as favourably as possible. In reply to Mr. Burnett, this also ,he said, was a matter which the Council, composed as it was of Engineer and Chairmen Members of the Association, would give their consideration to. On the other question of a discussion in camera on cooking, this again would be favourably considered by the Council. There had, he added, apparently been some misunderstanding in certain quarters as to why the meetings this year had been held in private, and although certain people could well understand why the Association should want to discuss the I.M.E.A. Bill in private, they could not understand why such a subject as heating and cooking should be dealt with in that way. It apparently was thought that the Association had met to discuss the question as to whether or not it was possible to cook electrically, and in these circumstances, perhaps it was advisable to explain that it was not for this reason, but because there were many points the members wished so discuss without hurting the feelings of manufacturers. Possibly the Council would be well advised to consider what should be done to put that right in the minds of the public.

Committee *re* Electric Vehicles.

Mr. F. Ayton said that at the meeting on the previous day in the discussion on the Paper on Electric Vehicles, he made the suggestion that this matter could be most favourably forwarded in its progress by appointing a Committee to deal with the whole matter thoroughly. He believed they would generally agree with him, that it was most important that they should support this matter well, because any mistakes which were made at the start would have the most prejudicial effect upon the progress

and the use of electric vehicles. He therefore moved the following resolution :

> " That a committee be appointed by the Council to consider and adopt such measures as may be found desirable to further the use of the electric battery vehicle ; that such committee be empowered to co-opt representatives of other institutions, company owned electric supply undertakings, manufacturers and others, directly interested in this matter."

They would see, he added, that he had endeavoured to word the resolution so that they would really get a representative committee. It was necessary to have the co-operation of all interests affected in this matter, and he hoped that the resolution would commend itself favourably to the meeting.

Mr. A. H. Seabrook, in seconding, said there was no time like the present to strike at this matter, and to get it going. One great advantage was that they would disturb much less important vested interests in pushing this new business than they had done in other directions in the past.

Mr. W. A. Vignoles (Chief Electrical Engineer, Grimsby) supported the resolution. There was, he said, some divergence of opinion on the previous day as to the best way of tackling this matter. Some of the members were in favour of corporations putting up battery charging stations and undertaking the repairs of vehicles, etc. He thought that a committee starting now would be able to consider that point, and he felt sure that they would arrive at some scheme by which the co-operation of members of three or four firms who were dealing with motors in each town, would be enlisted, so that charging stations could be arranged in existing garages, and in that way the assistance of private traders would be enlisted, and they would not be up against the troubles they had been in other schemes which they had put forward. The details of such a scheme could be worked out by this committee. Perhaps by means of a clock system one would be able to charge these garages at a small rate for the current used at times off the peak. In any case, the committee would be able to consider the whole matter carefully, and any recommendations they made would carry great weight with all the corporations and companies who are supplying electricity.

Mr. G. Wilkinson identified himself with the resolution and expressed his pleasure that Mr. Ayton had focussed his ideas in the form of a definite resolution. He hoped the Association would carry it out. From what he heard yesterday it was clear that those who were living in neighbourhoods where there was no tram service, could commence with effective self-contained electric vehicles whilst from the point of view of selling units from the supply station, he hoped the proposal would be pursued vigorously to some definite conclusion.

The President put Mr. Ayton's resolution to the meeting and it was carried unanimously.

At this point the meeting was declared private, and further discussion took place in camera.

SPECIAL GENERAL MEETING.

Articles of Association.

An extraordinary General Meeting was then held to consider the following resolution :

> " That the various Articles of Association be altered in the manner set forth in the document attached hereto."

OLD ARTICLES.

OFFICERS.

28. The Officers of the Association shall be a President a Senior and a Junior Vice-President three immediate past Presidents an Honorary Treasurer an Honorary Solicitor an Honorary Secretary and fourteen Ordinary Members of Council eight being Engineer Members of the Association and six Representatives of Municipalities being Members of the Association elected under these Articles and such Officers shall constitute the Council to direct and manage the concerns of the Association and a Secretary and one or more Auditors of Accounts.

Such Officers of the Association shall be elected or appointed in a manner hereinafter provided.

ELECTION OF COUNCIL.

29. The President Vice-Presidents Hon. Treasurer Hon. Solicitor Hon. Secretary four Engineer Members of the Council and three Municipal Representative Members of the Council shall retire annually.

No Member of the Association shall be eligible for election as President other than an Engineer Member who has previously served as a Member of the Council for two years and no Member of the Association shall be eligible for election as a Vice-President other than an Engineer Member who has previously served as an Ordinary Member of the Council.

The Secretary shall be appointed or dismissed by the Council.

The Members of the Council and all other Officers shall be elected by ballot at the Annual General Meeting and shall take office immediately after the Convention at which they are elected.

The Council may itself fill any casual vacancy on the Council but the Member appointed to fill the vacancy shall retain office so long only as the Vacating Member of the Council would in the ordinary way have retained the same.

The Annual Meeting of the Association shall be held during the Convention and nominations of Members of the Council and other Officers shall be made at such Annual Meeting.

NEW ARTICLES.

OFFICERS.

28. The Officers of the Association shall be a President a Senior and a Junior Vice-President three Immediate Past Presidents an Honorary Treasurer an Honorary Solicitor an Honorary Secretary and *fifteen* Ordinary Members of Council *nine* being Engineer Members of the Association and six representatives of Municipalities being Members of the Association elected under these Articles *and—if elected—one Honorary Member of Council* and such Officers shall constitute the Council to direct and manage the concerns of the Association and a Secretary and one or more Auditors of Accounts.

Such Officers of the Association shall be elected or appointed in a manner hereinafter provided.

ELECTION OF COUNCIL.

29A. The President Vice-Presidents Hon. Treasurer Hon. Solicitor Hon. Secretary, *three* Engineer Members of the Council and *two* Municipal Representative Members of the Council shall retire annually.

B. No Member of the Association shall be eligible for election as President other than an Engineer Member who has previously served as a Member of the Council for two years and no Member of the Association shall be eligible for election as a Vice President other than an Engineer Member who has previously served as an Ordinary Member of the Council.

C. The Secretary shall be appointed or dismissed by the Council.

D. *The Council may once in each year elect One Honorary Member of Council who shall hold office until the termination of the Annual Convention next following. Such Honorary Member of Council shall be a Member of the Committee of the Local Authority for whom the President of the Association for the period under consideration acts in the capacity of an Electrical Engineer.*

E. The *Ordinary* Members of the Council and all other Officers *other than those whose appointment is by these Articles under the control of the Council* shall be elected by ballot at the Annual General Meeting and shall take office immediately after the Convention at which they are elected *provided always that* the Council may itself fill any casual vacancy on the Council but the Member appointed to fill the vacancy shall retain office so long only as the Vacating Member of the Council would in the ordinary way have retained the same.

F. The Annual Meeting of the Association shall be held during the Convention.

The Financial Year of the Association shall end on the 31st day of March in each year.

THE HONORARY SECRETARY AND THE SECRETARY.

(40 and 41 remain unaltered.)

42. Except in cases of urgency notice shall be sent to those Members who reside in the United Kingdom at least seven days before the time appointed by the Council for such Special General Meeting.

G. *Not later than Fourteen days previous to the holding of the Annual Convention the Executive Council shall send to each member of the Association entitled to vote a list of duly qualified persons whom they nominate for the vacancies in the offices of President Vice Presidents Hon. Treasurer Hon. Secretary Hon. Solicitor and Ordinary Members of the Council.*

H. *The list of persons nominated by the Council for the office of Ordinary Member of Council shall contain the names of two Engineer Members and two Municipal Representatives in excess of the number of vacancies on the Council in those respective classes.*

J. *One of the persons nominated by the Council for the vacancies in the office of Ordinary Members of Council shall be the Electrical Engineer of a Local Authority other than a City or County Borough.*

K. *After the issue of the Council's list any three Members qualified to vote may nominate in writing any other duly qualified person to fill any vacancy subject to their having previously obtained the consent in writing of such person to accept office if elected. No such nomination shall be valid unless it shall have been delivered to the Secretary prior to two o'clock in the afternoon of the day previous to the date of the Annual General Meeting.*

L. *The voting at the Annual General Meeting shall be restricted to Members actually present at such Meeting and duly qualified to vote under the Articles of Association.*

M. *In the event of two or more candidates obtaining an equal number of votes for any vacancy or vacancies the result shall be determined by a re ballot.*

N. *No person shall hold the office of Ordinary Member of Council for more than three years in succession ; and no person who has previously held office as Ordinary Member of Council for a period of three years in succession or as an Immediate Past President shall hold office as an Ordinary Member of Council unless one year shall have elapsed since the expiry of such period of three years or since he last held the office of an Immediate Past President.*

P. The Financial Year of the Association shall end on the 31st day of March in each Year.

THE HONORARY SECRETARY AND THE SECRETARY.

(40 and 41 remain unaltered.)

42. Except in cases of urgency notice shall be sent to those Members who reside in the United Kingdom at least seven days before the time appointed by the Council for such Special General Meeting.

43. At any General Meeting unless a poll is demanded by at least five Members a declaration of the Chairman that a resolution has been carried and an entry to that effect in the book of the proceedings of the Association shall be conclusive evidence of the fact.

44. If a poll is demanded in manner aforesaid the same shall be taken in such manner as the Chairman directs and the result of such poll shall be deemed to be the resolution of the Association in General Meeting.

All Members and Associate Members shall have a right subject to the provision of Section 25 in these Articles to attend and vote and twenty-five shall constitute a quorum or such other number as may be directed from time to time at any Annual General Meeting.

43. At any General Meeting unless a poll is demanded by at least *ten* Members a declaration of the Chairman that a resolution has been carried and an entry to that effect in the book of the proceedings of the Association shall be conclusive evidence of the fact.

44. If a poll is demanded in manner aforesaid the same shall be taken in such manner as the Chairman directs and the result of such poll shall be deemed to be the resolution of the Association in General Meeting.

45. *At any General Meeting* all Members and Associate Members shall have a right subject to the provision of Section 25 in these Articles to attend and vote and twenty-five shall constitute a quorum or such other number as may be directed from time to time at any Annual General Meeting.

ENACTMENT OF BYE-LAWS AND REGULATIONS.

(Follow on without alteration but renumbered)

Mr. G. W. Pickvance moved that the matter be deferred for twelve months. He said that whether by accident or design, this very important question had been left to the end of the Meeting. Several attempts had been made to settle this trouble, and he did not think, with all due deference to any other opinions, that the matter would be satisfactorily settled that day. He therefore moved that the consideration of it be postponed, and that they should remain as they were for another twelve months.

The President asked why. These alterations had been very carefully considered and the Council felt in making them they had amply and fully met the views of the Association.

Mr. Pickvance said he did not think the suggested alterations did amply meet the views expressed at previous Meetings. He was of opinion, and so were others, that a fairly hearty discussion would ensue if time were given. The Meeting was then half empty and any expression of opinion given would not represent the opinion of the Association as a whole.

Mr. C. C. Atchison (Chief Electrical Engineer, Rochdale) said that he had in the past strongly supported Mr. Pickvance in the views which he held on this question, but having read the proposed alterations in the Articles of Association very carefully, he was of the opinion that they did meet the conditions and he would support them. He did not see that there was any need for an adjournment of the Meeting.

Mr. B. Sankey seconded Mr. Pickvance's resolution, which was then put to the Meeting and lost.

The alterations in the Articles of Association were then put to the Meeting *seriatim* and carried *nem. con.*

Votes of Thanks.

Bailie Smith (Glasgow) proposed a hearty vote of thanks to those who had contributed to the profit and the pleasure of the Meeting, for the courtesy which had been shown to the Association and for the hospitality that had been extended, and for the information that had been imparted to the members during the Convention. He moved that they most heartily thanked the Mayor of Kingston-upon-Thames, the Electricity Committee of

West Ham, the London Electric Supply Corporation, the London Electric Railway Company, for showing the members Lots Road Station, and to Mr. Bryan, Engineer at the Metropolitan Water Board, for allowing the members to visit the new Chingford Reservoir. He also included the Institution of Electrical Engineers for having provided the Association with a home during the Congress and also for all that the Institution had done for them during the week.

This resolution was seconded by Mr. A. G. Cooper, Chief Electrical Engineer, Colne, and carried with acclamation.

Bailie Stevenson (Edinburgh) moved a vote of thanks to the Honorary Officers which was also carried with acclamation.

Mr. T. Roles moved a vote of thanks to the B.E.A.M.A. for having undertaken the work in connection with the Exhibition of Cooking Appliances during the Convention. This was seconded by Mr. Chattock and carried.

Mr. F. W. Purse proposed a vote of thanks to the President for his conduct in the Chair which was seconded by Mr. Pickvance and carried.

The Proceedings then closed.

At the Extraordinary General Meeting of the Association held at the Institution of Electrical Engineers, Victoria Embankment, W.C. on Friday, July 11th, 1913, R. A. Chattock, Esq., President, in the Chair,

Mr. Chattock proposed, and Mr. H. Faraday Proctor seconded that the following Resolution, passed at the Extraordinary General Meeting held at the Institution of Electrical Engineers, on Friday, June 20th, 1913, viz.:

> "That the various Articles of Association be altered in manner set forth in the document attached hereto."

be confirmed.

The Resolution was put to the Meeting and carried *nem con.*

There being no other business, the Extraordinary General Meeting was declared closed.

Eighteenth Annual Convention, London, June 17th to 21st, 1913.

The headquarters of the Association was the "Hotel Cecil," the London meetings being held at the Institution of Electrical Engineers, Victoria Embankment, by kind permission of the Council of the Institution.

The approximate number of members, delegates and visitors was upwards of 550, constituting a record in point of numbers over any previous Convention.

A new feature in connection with the Convention was an exhibit of electrical appliances at the Institution, organised by the British Electrical and Allied Manufacturers Association under the auspices of the Incorporated Municipal Electrical Association.

The Convention was opened on June 17th by the President of the Institution of Electrical Engineers, Mr. W. Duddell, F.R.S., who extended a welcome to the members and delegates.

The President, having acknowledged Mr. Duddell's courtesy, read in the unavoidable absence of the author the address of the Ex-President, Mr. C. E. C. Shawfield, late Chief Electrical Engineer to the Corporation of Wolverhampton.

A Paper on "Prime Movers for Electric power," by Dr. S. Z. de Ferranti, Past-President of the Institution of Electrical Engineers, was then read and discussed.

In the afternoon visits were made to the Power House of the London Electric Supply Corporation, Ltd., and to the Corporation Electricity Works at West Ham.

On the following morning a discussion in camera took place on the Electric Lighting Bill and on Heating and Cooking, and after luncheon a visit was made to the London Electric Railway Power Station at Lots Road, Chelsea.

By kind permission of the "Electrical Times." *Photo—Jones & Son, Kingston-upon-Thames.*

EIGHTEENTH ANNUAL CONVENTION, LONDON, JUNE, 1913. MEMBERS AND DELEGATES AT HAMPTON COURT.

In the evening the Annual Dinner of the Association was held at the "Hotel Cecil," where the President presided over of gathering of 300 members, delegates and guests, including a number of ladies.

The after-dinner speakers included, besides the Chairman, the two Vice-Presidents, Mr. R. A. Chattock and Mr. H. Richardson, the President and Immediate Past-President of the Institution of Electrical Engineers, Mr. W. Duddell, F.R.S. and Dr. S. Z. de Ferranti, and the Mayor of Kingston-upon-Thames, Councillor C. H. Burge, F.I.C., Surrey C.C., and the following Past-Presidents of the Association:—Mr J. H. Rider, Mr. C. H. Wordingham and Mr. J. F. C. Snell.

A very enjoyable musical programme and entertainment was provided under the direction of Miss Haidee Hamilton, the other artists being Miss Annie Bartle, Miss Helen Mar, Mr. Walter Montague and Mr. Walter Emerson.

The meeting on June 19th was held at the Empire Theatre, Kingston-upon-Thames, where the Association was officially welcomed by the Mayor, Councillor C. H. Burge, F.I.C., Surrey C.C.

His Worship's kindness having been acknowledged by the President, the following papers were read and discussed: "Air Filtration," by Mr. J. Christie, Past-President, Chief Electrical Engineer, Brighton; and "Electric Vehicles," by Mr. W. H. L. Watson and Raymond L. Mitchell, which latter was followed by a demonstration of a number of battery-driven vehicles.

Luncheon was served in a Marquee on the lawn at Nuthall's, the party subsequently embarking on steam launches for a trip up the river. The return journey was broken at Hampton Court, where a photograph was taken in the Courtyard, after which the Gardens were visited.

The party then returned to Kingston for dinner at Nuthall's, subsequently proceeding to town by special train.

The Association is indebted to the courtesy of *The Electrical Times* for the use of the block in reproducing the photograph in the Proceedings.

The Annual General Meeting was held at the Institution on June 20th for the election of Officers and Council, and the transaction of other business, and was followed by a special general

meeting for the purpose of altering certain of the articles of Association, which alterations as recommended by the Council were agreed to.

On June 21st a visit was made by steam cars to King George's Reservoir at Chingford by kind permission of the Metropolitan Water Board.

Representatives of the following Local Authorities attended the Convention (152) :

Aberdeen, Accrington, Ashton-under-Lyne, Ayr, Barnes, Barnsley, Barrow-in-Furness, Batley, Beckenham, Bedford, Belfast, Bexley Heath, Birkenhead, Birmingham, Blackburn, Blackpool, Bolton, Bootle, Bradford, Bridlington, Brighton, Bristol, Broughty Ferry, Burnley, Burton-on-Trent, Bury, Bury St. Edmunds, Cambuslang, Canterbury, Cardiff, Carlisle, Cheltenham, Chester, Chesterfield, Cleckheaton, Colchester, Colne, Colwyn Bay, Coventry, Crewe, Croydon, Darlington, Dartford, Derby, Devonport, Dewsbury, Doncaster, Dover, Dundee, Ealing, Eastbourne, Eccles, Edinburgh, Epsom, Erith, Exeter, Fleetwood, Fulham, Gillingham, Glasgow, Gravesend, Great Grimsby, Greenock, Hackney, Halifax, Hammersmith, Hampstead, Harrogate, Hastings, Heywood, Hornsey, Hounslow, Hull, Ilford, Ilkeston, Ipswich, Kettering, Keighley, Kilmarnock, Kingston-upon-Thames, Lancaster, Leeds, Leek, Leith, Lincoln, Liverpool, Londonderry, Luton, Maidenhead, Maidstone, Malvern, Mansfield, Marylebone, Middlesbrough, Middleton, Morecambe, Motherwell, Nelson, Newcastle-under-Lyne, Newport (Mon.), Norwich, Nuneaton, Oldham, Pembroke (Dublin), Peterborough, Plymouth, Pontypridd, Poplar, Reading, Radcliffe, Rawtenstall, Rochdale, Rotherham, Salford, Sheffield, Shipley, Southampton, Southport, South Shields, Southwark, St. Anne's-on-Sea, St. Helen's, Stepney, Stirling, Stockton, Stoke-on-Trent, Stockport, Sunderland, Swansea, Swindon, Taunton, Todmorden, Torquay, Tunbridge Wells, Tynemouth, Wakefield, Wallasey, Walsall, Warrington, Watford, West Bromwich, West Ham, West Hartlepool, Weymouth, Whitehaven, Willesden, Wimbledon, Winchester, Wolverhampton, Worcester, Wrexham, York.

The following registered their attendance :

Committee Representatives (128).—Councillor E.T. Alms, Taunton; Councillor J. Ashworth, Heywood ; Councillor Atkinson, West Ham ; Councillor T. H. Bacon, Hammersmith ; Councillor

W. J. Bailes, Liverpool; Alderman G. Ball, Stockport; Councillor H. R. Barge, Poplar; Councillor Bates, Coventry; Alderman Sir J. Beecham, St. Helen's; Councillor A. Bell, Lancaster: Councillor W. J. Bellis, Wallasey; Councillor J. W. Booth, Stockport; Alderman Brodie, Blackpool; Councillor A. Broster, Leek; Alderman H. Brown, Leeds; Alderman W. Bruce, Sunderland; Councillor J. Calvert, Middlesbrough; Councillor Chamberlain, Maidenhead; Councillor S. Charlesworth, Bridlington; Councillor Clarke, Worcester; Councillor R. J. Clarke, Liverpool; Councillor G. H. Colwill, Swansea; Councillor W. F. Cooke, Nelson; Councillor W. Cooper, Bolton; Councillor H. Coupe, Rawtenstall; A. Coveney, Erith; Councillor Crowford, Accrington; Councillor J. W. Crowther, Sheffield; Alderman R. C. Davies, Chester; H. H. Denton, Crewe; E. H. L. Dickson, Salford; Councillor A. H. Dykes, Beckenham; Councillor A. Ebbs, Hammersmith; Councillor A. Edmeades, Winchester; Councillor A. G, Ellaway, Birmingham; D. M. Eunson, Cambuslang; Councillor Eyre, Plymouth; Councillor A. Fawcett, Halifax; Councillor J. P. Fielden, Rochdale; Alderman J. S, Finnigan, Belfast; Councillor Flanagan, Hull; H. Foulds, Birmingham; W. Frisby, Colchester; Councillor T. Gibb, Aberdeen; W. P. Gibbings, Carlisle; Councillor Gibson, Wolverhampton; Councillor J. Graham, Whitehaven; Bailie H. R. Grant, Motherwell; Councillor Hannay, Glasgow; Councillor Hargreaves, Burnley; Councillor J. H. Hargreaves, Hull; Councillor Heald, Lancaster; Councillor A. W. Heath, Birmingham; Councillor C. Higham, Blackburn; Councillor C. Hill, Hastings; F. H. Hill, St. Anne's-on-Sea; H. Hobday, Dover; Alderman Hodson, Exeter; Alderman T. Holmes, Gillingham; Councillor Holt, Blackpool; B. S. Hornby, Bolton; A. J. Howard, Taunton; Councillor J. Hustler, Bradford; Alderman Ingham, Southport; Alderman R. Irvin, Tynemouth; Councillor Jackson, St. Helen's; Councillor W. Jamieson, Bury; Alderman Jephcott, Birmingham; M. Jones, Pontypridd; Councillor J. E. Kilburn, Dewsbury; Alderman S. L. Kilpin, Bedford; Councillor S. G. Kimber, Southampton; Councillor King, Winchester; Councillor F. W. King, Bootle; Councillor J. H. King, Burton-on-Trent; Councillor W. Langdon, Torquay; Councillor Lee, Coventry; Councillor H. Leese, Stoke-on-Trent; R. Leigh, St. Anne's-on-Sea; Alderman Littler, West Ham; Alderman S. Lloyd, Bristol; Councillor J. H. Lofthouse, Harrogate; Councillor W. Longworth, Bolton; Alderman J. B. Love, Devonport; W. Love, Cambuslang; Councillor McDougall, Salford; W. B. McMillan, Greenock; W. J. Merrett, Cheltenham; Alder-

man D. B. Miller, Croydon; Councillor Morrin, Southport; Bailie J. M. Nairn, Dundee; Councillor Norkett, Maidenhead; Councillor O'Bryen, Hampstead; Alderman W. Pearson, Eccles; Councillor T. Philpot, Ilford; Councillor T. Reeves, Rotherham; Councillor E. J. Reid, Bexley; Councillor Reynolds, Shipley; Councillor G. M. Robertson, Fleetwood; Councillor Rothwell, Salford; Councillor T. Sauvage, Wrexham; Councillor Senington, Bristol; Councillor F. Seward, Lancaster; Alderman Sinclair, Swansea; Alderman Smethurst, Warrington; Bailie Smith, Glasgow; Alderman F. Smith, Liverpool; Alderman J. P. Smith, Barrow-in-Furness; D. Stenhouse, Glasgow; Judge Stevenson, Edinburgh; Councillor P. G. Stewart, Glasgow; Councillor Stirling, Doncaster; Councillor T. Sykes, Stockport; Councillor Thomson, Ayr; Councillor H. Tomkins, Stockton; Councillor Tomlinson, Bootle; Alderman Vaughan, Maidstone; Alderman West, Coventry; W. F. Wharmby, Mansfield; Councillor H. Whitehead, Keighley; Alderman W. G. Wilkins, Derby; H. Wilkinson, Radcliffe; Councillor J. Wilkinson, Warrington; Councillor A. Williamson, Greenock; Bailie Willock, Glasgow; Councillor J. H. Wilson, Hornsey; Councillor R. J. Wilson, Sunderland; Councillor Womersley, Wakefield.

Engineer Members (145).—R. L. Acland, Chesterfield; S. T. Allen, Wolverhampton; H. W. Angus, Eccles; N. Applebee, Ashton-under-Lyne; C. C. Atchison, Rochdale; F. Ayton, Ipswich; R. Ayton, Winchester; W. J. Bache, Cheltenham; W. J. R. Baker, Great Malvern; A. W. Barham, Watford; E. A. Barker, Barnsley; A. S. Barnard, Walsall; J. W. Beauchamp, West Ham; A. T. Beckett, Bridlington; H. Bell, Hull; J. A. Bell, Aberdeen; L. C. F. Bellamy, Ilkeston; W. C. Bexon, Kilmarnock; A. S. Black, Southport; A. S. Blackman, Sunderland; A. W. Blake, Willesden; C. A. Blascheck, Canterbury; T. W. Bloxam, Belfast; J. H. Bolam, Weymouth; H. Boot, London; J. H. Bowden, Poplar; J. Boyce, Todmorden; S. E. Britton, Chester; J. K. Brydges, Eastbourne; H. R. Burnett, Barrow-in-Furness; R. H. Campion, Dewsbury; R. M. Carr, Leek; A. D. Chalmers, Gillingham, W. A. Chamen, Cardiff (Hon. Member); R. A. Chattock, Birmingham; J. Christie, Brighton; S. Clegg, Lincoln; J. H. Clothier, St, Anne's-on-Sea; T. D. Clothier, Bootle; A. Clough, Liverpool; W. H. Cooke, Luton; A. G. Cooper, Colne; A. C. Cramb, Croydon; G. F. Craven, Reading; E. Cross, Rotherham; J. A. Crowther, Wallasey; C. S. Davidson, Mortlake, S.W.; S. E. Day, Bury St. Edmunds; A. J. C. de Renzi, Newcastle-under-Lyne; A. Dimmack, Swindon;

J. E. Edgcome, Kingston-upon-Thames ; H. S. Ellis, South Shields ; S. E. Fedden, Sheffield ; R. F. Ferguson, Hastings ; H. F. Friederichs, West Hartlepool ; A. J. Fuller, Fulham ; C. Furness, Blackpool ; S. Cameron Gibson, Nuneaton ; J. C. Gill, Peterborough ; A. C. Gilling, Epsom ; H. Gray, Accrington; T. Hall, Burton-on-Trent ; J. W. Hame, York ; E. H. Hewlett, Mansfield ; E. E. Hoadley, Maidstone ; L. B. Hogarth, Morecambe ; E. W. Hollingsworth, St. Helen's ; W. A. Jackson, West Bromwich ; S. D. Jones, Batley ; D. M. Kinghorn, Southwark ; J. D. Knight, Ealing ; W. W. Lackie, Glasgow ; R. B. Leach, Heywood ; H. Tomlinson Lee, Wimbledon ; R. Lomax, Stockport ; F. M. Long, Norwich ; J. R. P. Lunn, Darlington ; R. B. Macrory, Londonderry ; R. Marshall, Ayr ; F. V. L. Mathias, Warrington ; C. F. McInnes, Gravesend ; W. H. Miller, Fleetwood ; G. C. Milnes, Lancaster ; C. O. Milton, Maidenhead ; H. D. Munro, Exeter ; G. F. Naylor, Nelson ; H. A. Nevill, Wakefield ; F. A. Newington, Edinburgh ; S. W. Newington, Oldham ; E. G. Okell, Plymouth ; J. W. Papworth, Stirling ; S. Pauls, Middleton ; J. D. Pember, Dartford ; R. W. L. Phillips, Bedford ; A. Pickersgill, Cleckheaton ; W. G. Pickvance, Wrexham ; S. L. R. Price, Pembroke, Dublin ; H. Faraday Proctor, Bristol ; C. A. L. Prusmann, Swansea ; F. W. Purse, Carlisle ; E. S. Rayner, Doncaster ; W. Redman, Shipley ; H. Richardson, Dundee ; J. H. Rider, Johannesburg (Hon. Member) ; J. A. Robertson, Greenock ; L. L. Robinson, Hackney ; W. M. Rogerson, Halifax ; T. Roles, Bradford ; A. P. Rutherford, Leith ; P. E. Rycroft, Hounslow ; C. W. Salt, Torquay ; B. Sankey, Whitehaven ; A. H. Seabrook, Marylebone ; G, P. Shallcross, Birkenhead ; A. H. Shaw, Ilford ; C. M. Shaw, Worcester ; J. J. Smith, Stockton ; J. W. Spark, Devonport ; N. Staniland, Hornsey ; J. E. Starkie, Burnley ; C. L. E. Stewart, Rawtenstall ; H. P. Stokes, Bexley Heath ; H. F. Street, Southampton ; J. E. Tapper, Beckenham ; W. C. P. Tapper, Stepney ; H. M. Taylor, Middlesbrough ; J. E. Teasdel, Pontypridd ; R. N. Torpy, Tunbridge Wells ; G. Tough, Coventry ; A. R. Tudman, Colwyn Bay ; C. Turnbull, Tynemouth ; J. L. Turnbull, Broughty Ferry ; W. A. Vignoles, Grimsby ; W. A. Walker, Kettering ; S. J. Watson, Bury ; H. Webber, Keighley ; P. P. Wheelwright, Blackburn ; G. Wilkinson, Harrogate ; J. Wilkinson, Hull ; T. P. Wilmshurst, Derby ; J. A. Wishart, Motherwell ; L. W. Woodman, Dover ; C. H. Wordingham, London, (Hon. Member) ; W. Wyld, Hampstead ; C. H. Yeaman, Stoke-on-Trent.

Visitors (113).—H. M. Andrew, Huddersfield ; J. P. Annacker, London ; C. H. Archer, London ; E. P. Barfield, London ;

J. Bastian, London ; A. H. Bate, London ; M. Beales, London ; A. R. Bell, Uxbridge ; H. H. Berry, London ; D. Betts, London ; W. F. Bishop, London ; J. A. Blackwood, London ; H. E. Blain, West Ham ; H. H. Brooking, Warrington ; W. E. Burmand, Sheffield ; J. Bussey, London ; G. Campbell, London ; W. S. Carr, London ; G. S. Chisholm, London ; W. R. Cooper, London ; H. W. Couzens, London ; C. J. Cowan, London ; A. J. Cridge, London ; C. W. Crosbie, Bedford ; C. H. Davies, Whitton ; W. A. Dexter, Glasgow ; H. D. Dikes, North Finchley ; C. Dimmack, Swindon ; H. L. Dixon, Leatherhead ; A. R. Everest, Rugby ; Dr. S. Z. de Ferranti, Baslow ; C. Fox, London ; T. E. Gatehouse, London ; M. M. Gillespie, London ; W. A. Goreham, London ; R. A. Grey, London ; J. P. Gregory, London ; F. S. Grogan, London ; K. O. Hale, London ; R. Hammond, London ; F. G. Harris, London ; Haydn Harrison, London ; T. Martin Harvey, London ; A. J. Hedgcock, London ; R. Hill, London ; J. E. Hoggarth. London ; W. Holehouse, Bradford ; R. Hornby, London ; H. Howard, London ; J. S. Huddleston, London ; R. W. Hughman, London ; E. S. Hurlbatt, Manchester ; A. Jacob, London ; Dr. Juttke, London ; Dr. W. Koch, London ; F. Kershaw, London ; E. C. Laughton, London ; J. E. Lea, Manchester ; W. S. Lonsdale, London ; W. H. Lund, Manchester ; H. J. S. Mackay, London ; W. L. Madgen, London ; F. H. Maslet, London ; H. E. Midgley, London ; F. H. Nalder, London ; E. A. Nash, London ; E. S. New, London ; M. New, London ; F. H. E. Noel, London ; G. E. Partington, Manchester ; M. Petersen, London ; F. E. Phillips, London ; C. Pipkin, London ; J. S. Plumtree, London ; N. Prentice, Felixstowe ; C. C. Pudney, Bury St. Edmunds ; P. N. Rand, Manchester ; F. C. Raphael, London ; T. R. Renfree, London ; F. F. Robinson, London ; I. V. Robinson, West Hartlepool ; W. Robson, London ; H. S, Russell, Stockport ; H. Scholey, London ; G. D. Seaton, Manchester ; E. E. Sharp, London ; R. Wilson Smith, London ; C. H. Stedman, London ; G. D. Stone, London ; W. E. Storey, London ; B. A. Tapp, London ; F. Tarby, Mauritius ; C. T, Taylor, Rugby ; C. S. Thomson, London ; A. T. Turney, London ; A. Verdie, London ; J. S. G. Ward, London ; W. E. Warrilow, London ; T. Watlington, London ; H. J. G. Webb, London ; G. E. F. Webber, London ; R. W. Weekes, London ; A. G. Whyte; London ; H. T. Wilkinson, Manchester ; A. M. Willcox, London ; A. Williams, London ; A. D. Williamson, Sheffield ; C. Wilson, London ; D. Wilson, London ; W. J. Woodcock, London ; W. B. Woodhouse, Leeds ; A. W. Wynne, London ; R. P. Yates, London.

Ladies (19).—Mrs. Bell, Hull ; Mrs. J. A. Bell, Aberdeen ; Mrs. W. E. Burnand, Sheffield ; Mrs. Carr, Leek ; Mrs. J. Christie, Brighton ; Mrs. Eunson, Cambuslang ; Mrs. S. Z. de Ferranti, Baslow ; Mrs. Flanagan, Hull ; Mrs. Gibb, Aberdeen ; Mrs. Hargreaves, Hull ; Mrs. Lloyd, Bristol ; Mrs. Longworth, Bolton ; Mrs. Love, Cambuslang ; Mrs. Merrett, Cheltenham ; Mrs. J. J. Smith, Stockton ; Mrs. Thomson, Ayr ; Mrs. G. Wilkinson, Harrogate ; Mrs. J. Wilkinson, Hull ; Miss Wilkinson, Hull.

The following made returns, but did not register :

Committee Representatives (9).—Councillor Cracknell, Hammersmith ; T. Holt, Bury ; Councillor J. Morgan, Kingston Hill ; Alderman G. Pearson, Bristol ; Alderman G. H. Robinson, Bradford ; Alderman J. S. Rose, Barnsley ; W. G. Stansfield, Colne ; H. D. Turner, Willesden ; W. M. Wiggins, Middleton.

Engineer Members (4).—B. Rolling, Glasgow ; A. Nichols Moore, Newport, Mon. ; J. Pickersgill, Cleckheaton ; J. F. C. Snell, London (Hon. Member).

Visitors (43).—L. Andrews, London ; J. F. Avila, London ; G. Orme Bastian, London ; D. Bennett, London ; A. V. Bland, Morecambe ; J. L. Cateaux, London ; E. R. Cleaton, London ; A. G. Collis, London ; T. M. Colson, London ; W. Crawford, London ; F. Crawter, London ; F. R. Davenport, Rugby ; J. R. Dick, Oxford ; W. B. Esson, London ; O. Feldmann, London ; C. M. Forster, London ; A. H. Foyster, London ; W. Frier, London ; E. Garcke, London ; R. M. Gauntlett, London ; L. E. Harvey, Ilford ; G. E. Heath, London ; W. T. Hodgson, London ; G. Lloyd Jones, London ; H. P. Lawson, Bradford ; M. Leggett, London ; B. Longbottom, Manchester ; P. Von Miaskowski, London ; G. H. Nisbett, Prescot ; W. H. Owen, London ; C. Peel, London ; A. E. Perry, London ; C. C. Rattey, London ; P. T. Rose, Oxford ; R. H. Schofield, London ; H. C. Siddeley, London ; A. M. Sillar, London ; C. P. Sparks, London ; J. G. Statter, Manchester ; C. Stewart, Charlton ; H. W. Watts, Weybridge ; A. Wood, Bradford ; A. P. Wood, Manchester.

Ladies (89).—Mrs. Allen, Wolverhampton ; Mrs. Andrews, London ; Miss Andrews, London ; Mrs. Atkinson, West Ham ; Mrs. Ayton, Ipswich ; Mrs. Baker, Great Malvern ; Mrs. Barfield, London ; Mrs. Beales, London ; Mrs. Beauchamp, West Ham ; Mrs. W. F. Bishop, London ; Mrs. J. A. Blackwood, London ; Mrs.

Bolam, Weymouth ; Mrs. S. E. Britton, Chester ; Mrs. Brydges, Eastbourne ; Mrs. Burnett, Barrow-in-Furness ; Mrs. Calvert, Middlesbrough ; Mrs. Campion, Dewsbury ; Mrs. Chamberlain, Maidenhead ; Mrs. W. A. Chamen, Cardiff ; Mrs. Chattock, Birmingham ; Mrs. W. H. Cooke, Luton ; Mrs. Cooper, Bolton ; Mrs. Cooper, Colne ; Mrs. Cowan, London ; Mrs. Crosbie, Bedford ; Mrs. Davidson, Mortlake ; Mrs. R. C. Davies, Chester ; Mrs. Dimmack, Swindon ; Mrs. Ellis, South Shields ; Mrs. Forster, London ; Mrs. Foyster, London ; Mrs. Frier, London ; Mrs. Gillespie, London ; Miss Gray, Accrington ; Mrs. Hale, London ; Mrs. Hall, Burton-on-Trent ; Mrs. Hame, York ; Mrs. Hannay, Glasgow ; Miss Hannay, Glasgow ; Mrs. Hargreaves, Burnley ; Mrs. Haydn Harrison, London ; Mrs. Harvey, Ilford ; Mrs. T. M. Harvey, London ; Mrs. Heath, London ; Mrs. Hewlett, Mansfield ; Mrs. Higham, Blackburn ; Mrs. Hodson, Exeter ; Miss Hodson, Exeter ; Mrs. Howard, Taunton ; Mrs. Hustler, Bradford ; Mrs. W. Koch, London ; Mrs. Lackie, Glasgow ; Mrs. Laughton, London ; Mrs. Lea, Manchester ; Mrs. McDougall, Salford ; Mrs. P. von Miaskowski, London ; Mrs. Norkett, Maidenhead ; Miss Norkett, Maidenhead ; Mrs. Philpot, Ilford ; Mrs. Pickersgill, Cleckheaton ; Mrs. Price, Pembroke, Dublin ; Mrs. Rider, Johannesburg ; Miss Rider, Johannesburg ; Mrs. Robertson, Greenock ; Mrs. Robinson, Bradford ; Mrs. Robson, London ; Mrs. Roles, Bradford ; Mrs. Rolling, Glasgow ; Mrs. Rothwell, Salford ; Mrs. Rycroft, Hounslow ; Miss I. Sands, Whitehaven ; Mrs. Sankey, Whitehaven ; Mrs. A. H. Shaw, Ilford ; Mrs. Siddeley, London ; Mrs. R. W. Smith, London ; Mrs. J. F. C. Snell, London ; Mrs. Staniland, Hornsey ; Mrs. Stewart, Glasgow ; Mrs. C. Stewart, Charlton ; Mrs. Tapper, Beckenham ; Mrs. W. C. P. Tapper, Stepney ; Mrs. Taylor, Middlesbrough ; Miss Taylor, Middlesbrough ; Mrs. C. S. Thomson, London ; Mrs. J. C. G. Ward, London ; Mrs. Wheelwright, Blackburn ; Mrs. Williamson, Greenock ; Mrs. Willock, Glasgow ; Mrs. C. Wilson, London.

Summary :—

Municipal representatives	137
Municipal electrical engineers	148
Visitors	156
Ladies	108
Total	549

Incorporated Municipal Electrical Association.

Studentship Scheme.

Regulations and Conditions.

(1). The Council offers travelling studentships of the value of £10 each, for competition among Associates of the I.M.E.A., in the proportion of one studentship to every hundred Associates, or such other proportion as the Council may from time to time determine.

(2). Competitors shall be persons whose names are on the roll of Associates and who have paid their subscription for the current year.

(3). The Studentships will be awarded annually for the best papers submitted before March 31st on an approved subject, the holder being required to undertake before December 31st a tour of not less than one week's duration, for the purpose of visiting Electricity and Engineering Works.

(4). The successful candidates must within fourteen days of the award, notify the Secretary of the date of the commencement of the tour and particulars of the proposed itinerary and the works which it is desired to visit. They will then receive a sum of £7, and a travelling card of identification.

(5). A diary of the tour must be kept, which together with a detailed descriptive report must be sent to the Secretary within a month of the completion of the tour.

(6). Subject to the Council being satisfied from the evidence submitted that the holder has made proper use of his opportunties, a further payment of £3 will be made.

(7). All papers, etc., submitted in connection with the competition become the property of the Council.

(8). The Studentship may only be held once by the same person.

(9). The Council reserves the right of withholding any or all of the awards at its discretion.

All communications must be addressed to:—

C. McARTHUR BUTLER,
28, Bedford Square, W.C.

Winner of Studentship, 1907:—Mr. R. McCourt, Harrogate.
" " 1908:—Not awarded.
" " 1909:—Mr. E. Lunn, Huddersfield.
" " 1910:—Not awarded.
" " 1911:—Mr. V. T. Bush, Tunbridge Wells.
" " 1912:—Not awarded.
" " 1913:—Not awarded.

Incorporated Municipal Electrical Association.

FOUNDED 1895. INCORPORATED 1901.

LIST OF MEMBERS.

(*Those Municipalities in large type are represented on the Council.*)

COMMITTEES.

Date of Election.		Date of Election.	
1905	Aberdeen	1896	BRIGHTON
1902	Accrington	1896	BRISTOL
1901	Ashton-under-Lyne	1896	Burnley
1897	Ayr	1906	
1906	Barking	1904	Burton-upon-Trent
1900	Barnsley	1899	BURY
1898	BARROW-IN-FURNESS	1910	Cambuslang
		1907	Canterbury
1897	Bath	1897	Cardiff
1906	Beckenham	1900	Carlisle
1896	Bedford	1896	Cheltenham
1902	Birkenhead	1898	Chester
1903	Birkenhead Tramways	1901	Chesterfield
1904	BIRMINGHAM	1912	Clacton-on-Sea
1908	Blackburn	1909	Cleckheaton
1897	BLACKPOOL	1900	Colchester
1896	Bolton	1900	Colne
1903	Bolton Tramways	1912	Colwyn Bay
1902	Bootle	1896	Coventry
1903	Bournemouth Tramways	1909	Crewe
1896	BRADFORD	1896	CROYDON
1909	Bridlington	1900	Darlington

Date of Election	
1898	Darwen
1898	Derby
1893	Devonport
1896	Dewsbury
1901	Doncaster
1906	Dover
1903	Dublin
1901	DUNDEE
1899	Ealing
1900	Eastbourne
1904	Eccles
1901	Edinburgh
1908	Epsom
1903	Erith
1897	Exeter
1905	Falkirk
1904	Fulham
1908	Gillingham
1896	GLASGOW
1903	Gloucester
1904	Gravesend
1899	Great Grimsby
1908	Greenock
1896	Halifax
1897	Hammersmith
1912	HAMPSTEAD
1897	HARROGATE
1899	Hastings
1902	Heckmondwike
1912	Hereford
1902	Heywood
1908	Hornsey
1908	Horsham
1901	Hoylake
1896	Huddersfield
1897	Hull
1902	Hull Tramways
1902	Ilford
1903	Ilkeston
1906	Keighley
1907	Kilmarnock
1906	King's Lynn
1896	KINGSTON-UPON-THAMES
1902	Lancaster
1901	Leeds
1905	Leek
1911	Leicester
1901	Leigh
1908	Leith
1901	Leyton
1897	Lincoln
1896	Liverpool
1903	Londonderry
1906	Loughborough
1899	Lowestoft
1896	Luton
1897	Maidenhead
1902	Maidstone
1896	MANCHESTER
1904	Mansfield
1902	Middlesbrough
1902	Middleton
1898	Morley
1901	Motherwell
1902	Nelson
1897	Newport (Mon.)
1907	Northampton

Date of Election	
1909	Norwich
1903	Nottingham
1902	Nuneaton
1903	Oldham
1909	Pembroke (Dublin)
1896	Plymouth
1908	Pontypridd
1912	Poplar
1904	Portsmouth
1901	Reading Tramways
1908	Radcliffe
1910	Rawtenstall
1896	Rochdale
1897	Rotherham
1897	Salford
1904	SHEFFIELD
1901	Shipley
1897	Southampton
1896	Southend-on-Sea
1897	Southport
1902	South Shields
1903	St. Annes-on-Sea
1898	St. Helen's
1899	St. Pancras
1910	Stirling
1903	Stockton
1903	Stoke-on-Trent
1898	Stockport
1896	SUNDERLAND

Date of Election.	
1913	Sutton Coldfield
1902	SWANSEA
1902	Swindon
1896	Taunton
1909	Todmorden
1897	Torquay
1896	Tunbridge Wells
1903	Tynemouth
1901	Wakefield
1896	Wallasey
1896	Walsall
1908	Warrington
1897	Watford
1913	West Bromwich
1897	West Ham
1906	Weymouth
1912	Whitehaven
1901	Wigan
1900	Willesden
1908	Wimbledon
1912	Winchester
1906	Wishaw
1898	WOLVERHAMPTON
1906	Woolwich
1896	Worcester
1913	Worksop
1903	Wrexham
1901	York

ELECTRICAL ENGINEERS (MEMBERS)

Names of Members of Council are in larger type

Date of Election.		
1901	Acland, R. L.	Chesterfield
1900	Atchison, C. C.	Rochdale
A 1902 M 1908	Allen, Sidney	Wolverhampton
1909	Allen, W. H. ..	Loughborough
1902	Angus, H. W.	Eccles
1901	Applebee, N.	Ashton-under-Lyne
1906	AYTON, F.	Ipswich
1912	Ayton, R.	Winchester
1903	Bache, W. J.	Cheltenham
1908	Baker, W. J. R. ..	Malvern
1913	Barham, A. W.	Watford
1903	Barker, E. A.	Barnsley
1895 1908	Barnard, A. S. (*Past Vice-President* 1900)	Walsall
1910	Beauchamp, J. W. ..	West Ham
1913	Beckett, A. T.	Bridlington
1903	Bell, H.	Hull
A 1896 M 1899	Bell, J. A.	Aberdeen
1906	Bell, G. G.	Hammersmith, W.
1913	Bellamy, L. C. F. ..	Ilkeston
1912	Bexon, W. C.	Kilmarnock
1908	Black, A. S.	Southport
1896	Blackman, A.	Sunderland
1912	Blake, A. W.	Willesden
1907	Blascheck, C. A.	Canterbury
1908	Bloxam, T. W.	Belfast
1908	Bolam, J. H.	Weymouth
1896	Boot, H. (*Past Member of Council* 1906)	Tunbridge Wells
1906	Bowden, J. H.	Poplar, E.
1901	Britton, S. E.	Chester
1898	Brydges, J. K. (*Past Member of Council* 1908)	Eastbourne

Date of Election.		
1905	Bulfin, I.	Bournemouth
A 1896 M 1898	Burnett, H. R.	Barrow-in-Furness
1901	Calvert, E.	Finchley, N.
1902	Campion, R. H. ..	Dewsbury
1905	Carr, R. M.	Leek
1907 1913	Chalmers, A. D... ..	Gillingham
1900	CHATTOCK, R. A. (*President* 1913–14)	Birmingham
M 1895 A 1898 M 1900	CHRISTIE, J. .. .. (*Past President* 1911.)	Brighton
A 1896 M 1898	Clegg, Stanley	Lincoln
1902	Clothier, J. H.	St. Anne's-on-Sea
A 1898 M 1902	Clothier, T. D.	Bootle
1903	Clough, A.	Liverpool
1902	Cooke, W. H.	Luton
A 1895 M 1900	Cooper, A. G.	Colne
A 1900 M 1904	CRAMB, A. C. .. .. (*Vice-President* 1913–14)	Croydon
1913	Craven, G. F.	Reading
1909	Cross, E.	Rotherham.
1900	Crowther, J. A... ..	Wallasey
1901	Crowther, J. P.	Worksop
1902	Davidson, C. S... ..	Mortlake, S.W.
1913	De Renzi, A. J. C. ..	Newcastle-under-Lyne
1896	Dickinson, H. (*Past Vice-President* 1901)	Liverpool
1908	Dimmack, A.	Swindon
1904	Duesbury, T.	Sutton Coldfield
1895	EDGCOME, J. E. (*Hon. Treas. Past Pres.* 1906, *Hon. Secretary* 1904)	Kingston-upon-Thames
1895	Ellis, A. (*Past Member of Council* 1902)	Cardiff

Date of Election.		
1912	Ellis, H. S.	South Shields
1909	Everitt, H. W.	Clacton-on-Sea
A 1896 M 1899	FEDDEN, S. E. .. (*Past President* 1907)	Sheffield
1903	Ferguson, R. F. ..	Hastings
1902	Ferguson, W. J. ..	Redditch
1903	Foale, W. S.	Portsmouth
1909	Francis, O. F.	Kirkcaldy
1901	Friederichs, H. F. ..	West Hartlepool
1904	Fuller, A. J.	Fulham, S.W.
1899	FURNESS, C.	Blackpool
1905	Garside, F.	Aldershot
1912	Gibson, S. Cameron ..	Nuneaton
1901	Gill, J. C.	Peterborough
1903 1913	Gilling, A. C.	Epsom
1906	Goslin, E. T.	Glasgow Trams
1901	Grey, H.	Accrington
1911	Hall, T.	Burton-upon-Trent
A 1906 M 1908	Hame, J. W.	York
1906	Hatton, E.	Newcastle-upon-Tyne
1911	Hawkins, H. J.	Salford
1904	Hewlett, E. H.	Mansfield
A 1898 M 1900	Hoadley, E. E. (*Past Member of Council* 1907)	Maidstone
1910	Hogarth, L. B.	Morecambe
A 1899 M 1903	Hollingsworth, E. M. ..	St. Helen's
1907	Jackson, W. A.	West Bromwich
1913	Kay, Barnes	Haslingden
1909	Kerr, W. T.	Hereford
1903	Kinghorn, D. M. ..	Southwark, S.E.
1900	Knight, J. D.	Ealing, W.
A 1896 AM 1898 M 1905	LACKIE, W. W. .. (*Past President* 1910)	Glasgow

Date of Election.		
1906 / 1913	Leach, R. B.	Heywood
1913	Lee, H. Tomlinson ..	Wimbledon
1898	Lewis, F. H.	Leytonstone, E.
1909	Lomax, R.	Stockport
1908	Long, E. D.	Grays Thurrock
1903	Long, F. M. (*Past Member of Council*, 1912)	Norwich
A 1896 / M 1901	Lunn, J. R. P.	Darlington
1901	Macrory, R. V.	Londonderry
1903	Marshall, R.	Ayr
1908	Mathias, F. V. L. ..	Warrington
1903	McInnes, C. F.	Gravesend
1913	Miller, H. W.	Fleetwood
1911	Milnes, G. C.	Lancaster
1912	Moore, A. Nichols ..	Newport, Mon.
A 1896 / M 1898	Morton, A. H.	Llandudno
1895	Mountain, A. B. (*Past Pres.* 1900, *and Hon. Secretary* 1896)	Huddersfield
1896	Munro, H. D.	Exeter
1913	Nayler, G. F.	Nelson
1909	Nevill, H. A.	Wakefield
1896	Newington, F. A. (*Past President* 1905)	Edinburgh
1903	Newington, S. W. ..	Oldham
A 1897 / M 1901	Okell, E. G.	Plymouth
1905	Page, A.	Glasgow
1910	Papworth, J. W. ..	Stirling
1898	Parkinson, C. F. ..	Paisley
AM 1902 / M 1903	Parsons, T. C.	Govan
1904	Pauls, S.	Middleton

Date of Election		
AM 1903 / M 1904	PEARCE, S. L. .. (*Past-President* 1909)	Manchester
1901	Pember, J. D.	Dartford
A 1896 / M 1902	Phillips, R. W. L. ..	Bedford
1909	Pickersgill, A.	Cleckheaton
1909	Pickvance, G.	Wrexham
1906	Plunkett, M. P.	Tonbridge
1912	Price, S. L. R.	Pembroke (Dublin)
1895	PROCTOR, H. FARADAY (*Hon. Secretary, Past Pres.* 1899)	Bristol
A 1897 / M 1900	Prusmann, C. A. L. ..	Swansea
1909	Purse, F. W.	Carlisle
1912	Ranson, H.	Falkirk
1904	Rayner, E. S.	Doncaster
1913	Redman, W.	Shipley
1904	RICHARDSON, H. .. (*Vice-President* 1912-13)	Dundee
1904	Robertson, J. A. ..	Greenock
1902	Robinson, L. L.	Hackney, N.E.
1902	Rogerson, W. M. ..	Halifax
1908	ROLES, T.	Bradford
1902	Ruddle, M.	Dublin
1904	Rutherford, A. P. ..	Leith
1911	Rycroft, P. E.	Hounslow
1911	Salt, C. W.	Torquay
1908	Sankey, B.	Whitehaven
1902	SEABROOK, A. H. ..	St. Marylebone
1909	Senior, J.	Mexborough
1901	Shaw, A. H.	Ilford, E.
1903	Shaw, C. M.	Worcester
1906	Slevin, J.	Wigan
1906	Smith, Arthur T. ..	Leigh, Lancs.

Date of Election.		
1903	Smith, J. J.	Stockton-on-Tees
1912	Smith, T. R.	Leicester
1903	Spark, J. W.	Devonport
1904	Staniland, N.	Hornsey, N.
1906	Starkie, J. E.	Burnley
1910	Stewart, C. L. E. ..	Rawtenstall
1910	Stokes, H. P.	Bexley Heath
1901	Street, H. F.	Southampton
1895	Talbot Herbert .. .. (*Past President* 1908)	Nottingham
1909	Talbot, Henry	
1909	Tapper, J. E.	Beckenham
A 1896 / M 1900	Tapper, W. C. P. ..	Stepney, E.
1902	Taylor, H. M.	Middlesbrough
1898	Teague, F. .. .	Bath
A 1896 / M 1906	Teasdel, J. E.	Pontypridd
1913	Torpy, R N.	Tunbridge Wells
1910	Tough, G.	Coventry
1909	Tudman, A. R. ..	Colwyn Bay
1900	Turnbull, C.	Tynemouth
1908	Turnbull, J. L. ..	Broughty Ferry
1907	Turner, C.	Hoylake
1901	Vignoles, W. A.	Grimsby
1911	Walker, W. A.	Kettering
1898	WATSON, S. J.	Bury
1910	Webber, H.	Keighley
AM 1904 / M 1905	Wheelwright, P. P. ..	Blackburn
1909	Whysall, F. H.	Manchester
1897	WILKINSON, G. .. (*Past President*, 1912)	Harrogate
1903	Wilkinson, J.	Hull Tramways

Date of Election.		
1895	Wilmshurst, T. P. (*Past Pres.*, 1904).	Derby
1907	Wilson, W. H.	Sleaford
1911	Wishart, J. A.	Motherwell
1906	Woodman, L. W. ..	Dover
1897 M 1902	WYLD, W.	Hampstead
A 1896 M 1905	Yeaman, C. H.	Stoke

HON. MEMBERS.

M 1898 1905	Chamen, W. A. (*Past Pres.*, 1901).	Cardiff
M 1896 1903	Holmes, A. B. (*Past Mem. of Council*, 1898).	Liverpool
M 1895 1911	Rider, J. H. (*Past Pres.*, 1901–2).	Johannesburg
M 1898 1913	Shawfield, C. E C. (*Past Pres.* 1912–13)	Wolverhampton
M 1906 1909	Snell, J. F. C. (*Past Pres.* 1902-3).	London
M 1895 1910	Wordingham, C. H. .. (*Past President* 1898)	London

ASSOCIATE MEMBERS.

CHIEF ASSISTANT ENGINEERS

1912	Hudson, J. Barcroft ..	Bootle
1905	Lamb, C.	Dundee
1907	Ratcliff, H. A.	Manchester
1910	Yorke, W.	Sunderland

ASSOCIATES.

ASSISTANT ENGINEERS.

Date of Election.		
1903	Adams, W.	Stoke
1903	Boyce, J.	Todmorden
1911	Bush, V. F.	Tunbridge Wells
1901	Cairns, R.	Glasgow
1902	Channon, A. S.	Grimsby
1903	Day, S. E.	Bury St. Edmunds
1910	Dent, J. H.	Loughborough
1906	Douglas-Arden, G... ..	Derby
1904	Fairchild, J. C.	St. Annes-on-Sea
1899	Gilbert, A. C.	Edinburgh
1911	Hooper, W. P.	Dewsbury
1901	Howell, A.	Hornsey, N.
1904	James, E. W.	Hounslow, W.
1902	Jones, S. Derwen	Batley
1904	Lowe, J. W.	Wigan
1909	Lunn, E.	Huddersfield
1897	May, H. S.	London
1907	McCourt, R.	Harrogate

Date of Election		
1912	McDonnell, E.C.	Bootle
1902	Millington, W. G.	Peterborough
1899	Milton, C. O.	Maidenhead
1910	Murray, J. R. C.	
1903	Nixon, A. T.	Sheffield
1902	Ogden, F. L.	Oldham
1896	Philpott, G. J	Brighton
1904	Rolling, B. I.	Glasgow
1911	Saxton, C.	Wakefield
M 1897 A 1898	Shallcross, G. P.	Birkenhead
1902	Thomson, J.	Leith
1898	Turner, J. W.	Huddersfield
1897	Whitwham, A. E. ..	Huddersfield
1902	Young, W.	Stepney, E.

SUMMARY.

Committees.	Members	166
Engineers.	„	177
„	Hon. Members	6
Assistants.	Associate Members	4
	Associates	32
		385

Past Presidents of the I.M.E.A.

Date.	Name.	Convention Centre.
1895–6	A. Wright	London.
1896–7	C. H. Wordingham	Manchester.
1897–8	W. Arnot A. H. Gibbings	London.
1898–9	H. Faraday Proctor	Bristol.
1899–0	A. B. Mountain	Huddersfield.
1900–1	W. A. Chamen	Glasgow.
1901–2	J. H. Rider	London.
1902–3	J. F. C. Snell	Sunderland.
1903–4	T. P. Wilmshurst	Derby.
1904–5	F. A. Newington	Edinburgh.
1905–6	J. E. Edgcome	London.
1906–7	S. E. Fedden	Sheffield.
1907–8	H. Talbot	Nottingham.
1908–9	S. L. Pearce	Manchester.
1909–10	W. W. Lackie	Glasgow.
1910–11	J. Christie	Brighton.
1911–12	G. Wilkinson	Harrogate.
1912–13	C. E. C. Shawfield J. E. Edgcome	London.

PUBLICATIONS

OF THE

Incorporated Municipal Electrical Association

Author.	Title.	Date.
Acland, R. L.	Extension of Electricity Supply to outlying districts	1907
Andrews, L.	The Distribution of Electricity in Scattered Areas	1900
Ayton, F.	Cheapening of the Cost of Mains and Services	1910
	Means for Securing Reliability and Maintaining Continuity of Supply	1912
Barnard, A. S.	Electricity Supply at 220 Volts.	1896
	High Tension Continuous Current Systems	1902
Baynes. S. W.	Steam Turbines	1906
Beauchamp, J. W.	Modern Wiring Practice	1911
Bishop, H. Collings	Means for Stimulating a Demand for Electrical Energy	1900
	The Commercial Development of Electricity Undertakings	1906
	Notes on the Commercial Progress of Electricity Undertakings	1910
Blackman, A. S.	Steam Turbines from the User's Point of View	1909
Blaikie, J. R.	Distributing Systems	1897
	Switchboard Apparatus	1898
Blakeway, Councillor.	The Financial Possibilities of Municipal Electrical Undertakings	1904
Boot, H. L. P.	Street Lighting by Electricity	1897
	Method of Reducing Light and Load Losses	1900
	The Management and Working of Boilers	1903
Bremner, Ashton	Extensions to existing Electricity Supply Stations by means of Mixed Pressure Turbines	1910
Burnett, H. P.	The Costs of Electrical Supply and their Relation to Scales of Charges	1907
Bush, Valentine F.	The Motor Meter as applied to the Measurement of Single Phase Alternating Current	1911
Carr, R. M.	Internal Combustion Engines in Power Stations	1911

Author.	Title.	Date.
Chamen, W. A.	Presidential Address -	1901
	The Possibilities of Future Economies in Electrical Illumination - - -	1903
Chattock, R. A.	Coal and Ash Conveying Gear - -	1901
Christie, J.	Presidential Address - - - -	1911
	Air Filtration - - - -	1913
Clothier, T. D.	Electric Lighting Mains - -	1899
Couzens, H. W.	Alternating Current Stations and High Voltage Lamps - - - -	1896
	Prepayment Meters - - - -	1897
Cramb, A. C.	Commercial Advancement of Electrical Supply - - - - - -	1910
Cridge, A. J.	The Organisation and Management of a Central Station Meter Department-	1904
	Some Notes on Alternating Current Distribution - - - -	1907
Day, Arthur A.	The Correct Type of Engine for Large Generating Stations - - -	1902
Downe, R. S.	Boiler House Economies - - -	1904
Edgcome, J. E.	The Arrangement of Steam and other Pipes, and their Fittings- - -	1899
	Presidential Address - - - -	1906
Fedden. S. E.	Street Lighting by Electricity - -	1897
	Steam Turbines - - - - -	1902
	The Commercial Development of Electricity Undertakings - -	1906
	Presidential Address - - - -	1907
Fell, A. L. C.	Braking Apparatus for Electric Cars-	1901
Ferranti S. Z. de	Prime Movers for Electric Power -	1913
Gibbings, A. H.	Extensions to Outlying Districts -	1896
	Municipal Aids to Wiring - - -	1897
	Presidential Address - - - -	1898
Harris, G. M.	Electricity Works for Small Towns -	1900
Hesford, Councillor.	The Management of Electricity Undertakings - - - - - -	1898
Hesketh & Rider.	Combined Electric Lighting and Traction plants - - - -	1896
Hewitt, F. W.	Fuses - - - - - -	1903
Highfield, J. S.	Refuse Destructors in Combination with Electric Power Stations - - -	1901
Hoadley, E. E.	Street Lighting - - - - -	1905
	The influence of metallic filament lamps on the Electrical industry and on Street Lighting - - - -	1909

Author.	Title.	Date.
Hodgson, Councillor.	The Supply of Electricity in Industrial Areas from a Municipal Point of View	1905
Hollingsworth, E. M.	Modern Cable Systems - - -	1909
Holmes, H. H.	Electric Cooking Apparatus- - -	1912
Howard, H. L.	Internal Combustion Engines in Power Stations - - - - - -	1911
Howard, H.	Steam Turbines : Their Efficiency compared with Reciprocating Engines -	1904
Jeckell, J. A.	Cable Specifications and Tests - -	1896
	Distributing Systems - - - -	1897
	Steam Using Plant - - - -	1898
	The Financial Improvement of Electricity Supply Works - - -	1903
Kilgour, H.	Notes on Costs and Tariffs for Electric Supply - - - - - -	1905
Lackie, W. W.	Presidential Address - - - -	1910
Le Rossignol, A. E.	Impressions of Present American Tramway Practice - - - -	1900
	Electric Traction as Applied to the Newcastle Tramways - - -	1903
Leese, Councillor H.	Electricity Supply viewed from the Municipal Committee's Standpoint -	1911
Long, F. M.	A Cooking Load from the Supply Station point of view. - - -	1912
Lunn, E.	Notes on Condensing and Water Cooling Plant - - - - -	1906
Lunn & Thompson	Notes on the Performances of Single Phase Motors - - - - -	1899
Maclay, Baillie	Appropriation of Profits and Repayments of Loans - - - -	1898
	Do. do. do. - - - -	1899
	Notes on Street Lighting - - -	1901
McCourt, R.	The Value of Photometry in Central Station Practice - - - -	1907
Mountain, A B.	Electricity Works Records - - -	1896
	The Municipalisation of the Telephone -	1899
	Presidential Address - - -	1900
	Extensions to Outlying Areas - -	1905
Murray, J. R. Campbell	Steam Power Generation. The Advantages of Mechanical Draft - -	1911
Newington F. A.	Presidential Address - - - -	1905
	Exhaust Steam Turbines and Condensing Plant - - - - -	1910

Author.	Title.	Date.
PANTON, COUNCILLOR.	Some Observations on Electricity Supply and Methods of Stimulating Demand - - - - - - -	1903
PEARCE, S. L.	Polyphase Sub-stations: Their Equipment and Working - - - -	1904
	Presidential Address - - - -	1909
	The Limitation of Rate Relief from Profits - - - - - - -	1912
PEARSON, ALDERMAN.	Municipal Trading - - - -	1899
	The Sphere of Utility of a Power Company - - - - - -	1903
POTTER, ALDERMAN.	Means for stimulating Demand for Electrical Energy - - - - -	1900
PROCTOR, H. FARADAY.	Presidential Address - - - -	1899
	Notes *re* Earthing - - - -	1902
	Some Notes on the Bristol Electricity Fire- - - - - - -	1904
PRUSSMANN, C. A. L.	The Choice of Meters - - - -	1899
	Electric Motors - - -	1900
QUIN, R. C.	Localisation of Faults- - - -	1897
	Electric Traction - - - -	1900
	Protection of Telegraph and Telephone Wires - - - - - - -	1900
RATCLIFF H. A.	The Work and Equipment of a Testing and Standardising Department - -	1908
REID, A. M.	Reliability of the "Total Costs per Unit Sold" - - - - - -	1913
RICHARDSON, H.	Some Considerations on the Design of a Generating Station - - - -	1908
RIDER, J. H.	Use of Accumulators -	1898
	Combined Lighting and Traction Works	1899
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	Double Current Generators and their Application - - - - - -	1902
SEABROOK, A. H.	Street and Shop Front Lighting - -	1911
SHAW, C. M.	The Reconstruction of an Electric Lighting Scheme - - - - -	1908
	Organization in Electricity Supply Undertakings - - - - - -	1912
SHAWFIELD, C. E. C	The Commercial Practicability of Electric Traction by Surface Contact -	1904
	Cheap Power Supply by Municipalities	1907
	Advantages of Continuous Records of Cost and of Steam Consumption -	1910
	Purchase of Fuel - - - - -	1911
	Presidential Address - - - -	1913

Author.	Title.	Date.
Sillar, A. R.	Free Wiring and Supply on the Prepayment System	1905
Sinclair, Councillor.	Load Factor: Its Effect upon an Electricity Station	1905
	Cheap Units	1909
Smith, Alderman, J.P.	Some Statistics of Electrical Supply	1903
Snell, J. F. C.	Generation of Steam	1897
	Single *versus* Multiple Generating Stations	1898
	Condensers for Electric Lighting and Power Stations	1899
	The Relative Advantages of Two and Three Wire Distribution	1902
	Presidential Address	1903
	Relative Economies of Electric Supply from Small Local Stations and from Power Companies	1906
Steinitz, J. J.	Generation of Steam	1896
Stewart, J. E.	Electric Traction	1898
Stewart, C. L. E.	Low Tension Continuous Current Switchgear	1903
Taite, C. D.	Street Lighting by Electricity	1897
	Notes on the Distribution of Electricity	1899
Talbot, H.	Presidential Address	1908
Taylor, A. M.	Alternating Current Accumulator Sub-Stations	1908
Tittensor, W. H.	The Equitable Allocation of Costs in Combined Lighting and Traction Stations	1901
Vesey Brown, C. S.	Electricity Works for Small Towns	1900
Vignoles, W. A.	The Efficiency of Steam Plant	1906
Watson, S. J.	The Supply of Power to Tramways from small Stations	1906
	Cheapening of the Cost of Mains and Services	1910
	Automatic Pressure Regulations	1912
Watson & Mitchell	Electric Automobiles	1913
Wightman, Bailie.	The Experiences of a Convener in the Establishment of an Electricity Undertaking	1908
Wilkinson, G.	The Distribution of Electricity in Scattered Areas	1900
	Live Steam Heated Feed Water, its Effect on the Output and Efficiency of Steam Boilers	1906
	Advantages of Continuous Records of Costs and of Steam Consumption	1910
	Presidential Address	1912

Author.	Title.	Date.
WILMSHURST, T. P.	Electric Meters - - - - -	1899
	Do. Motors - - - - -	1900
	Presidential Address - - - -	1904
WORDINGHAM, C. H.	The Control by Municipal Authorities of Consuming Devices, and the Wiring connecting them to the Mains - -	1896
	Presidential Address - - - -	1897
	On the Necessity of Uniformity in Plant and Apparatus - - - -	1898
	Maintaining Certain Portions of Electrical Distribution Systems at Earth Potential - - - - -	1900
WRIGHT, A.	Presidential Address - - - -	1896
YEAMAN, C. H.	Depreciation and Reserves for Antiquation and Obsolescence, from an Engineering Standpoint - - -	1907

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PROCEEDINGS

OF THE

NINETEENTH ANNUAL CONVENTION

OF THE

INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION,

BIRMINGHAM,

June 16th to June 20th, 1914.

REPORTED BY ARRANGEMENT WITH "ELECTRICAL ENGINEERING."

TUESDAY, JUNE 16th.

MEETING IN THE BIRMINGHAM AND MIDLAND INSTITUTE.

The Association met at 10 a.m., and was welcomed by the Rt. Hon. the Lord Mayor of Birmingham, the Lieut.-Colonel Ernest Martineau.

The Lord Mayor said he would be very brief in view of the heavy programme which the Association had to get through, and of the fact that the Lady Mayoress and himself would have the opportunity of sharing their hospitality in the evening and of welcoming the members individually on the following day. At the ame time he was very glad indeed to welcome an Association consisting of so many

people from all parts of the country. He was afraid, however, that from the purely municipal electrical point of view, the Association had come to Birmingham at the wrong moment, they were at a stage of municipal electrical development which meant that all their plant was now working up to its full capacity, and was not quite of the most modern description. The new undertaking of the Birmingham Corporation consisted at present of a piece of land, some designs and some contracts. These were not very favourable things to show to an Association. At the same time there were a great many electrical industries in Birmingham which would be of great interest to them, and he hoped they would be afforded full facilities for viewing them. He wished the Association a prosperous and useful conference, and that they would not only obtain valuable results from it, but would go away with a pleasant recollection of the City and the citizens of Birmingham.

The President, Mr. R. A. Chattock (Birmingham), thanked the Lord Mayor in the name of the Association for the welcome extended to them.

Incorporated Municipal Electrical Association,

BIRMINGHAM CONVENTION, 1914.

Address

GIVEN BY MR. R. A. CHATTOCK.

In presenting this address to you to-day, first let me thank you for the honour you did me in electing me as your President, and I would also like to say here how pleased I am to see Birmingham honoured by so large and representative a gathering of municipal and other engineers and members of electric supply committees.

There are several points on which I wish to touch before coming to the main portion of my address.

(1) MODEL GENERAL CONDITIONS.—It is a matter of regret that the contentious clauses in the model general conditions have not yet been agreed between this Association and the British Electrical and Allied Manufacturers'

Association. A set of model general conditions has recently been issued by the Institution of Electrical Engineers without the approval of our Association, and I feel that this is a direct result of the strong opposition manifested by some of the members of this Association at the special meeting held in July last. The result is that these Institution model conditions, which are at variance with our ideas in many respects, are now being put forward by manufacturers with the authority of the Institution behind them, and buyers are being obliged to accept them without much hope of negotiating alterations in them. I cannot help feeling that a very different result, and one more favourable to us, would have been obtained if members of this Association had adopted the carefully considered recommendations of the Council twelve months ago, or possibly varied them to only a small extent, and allowed the negotiations with the manufacturers to go on with a view to an amicable settlement of points on which there was a difference between the two Associations.

As it is, the Council have discussed the contentious clauses and the suggestions made at the meeting in July last, with the Association of Municipal Corporations. This Association promised to take the matter in hand and draft clauses in legal terms which were then to be submitted to our Association. We have been waiting now for many months for this draft, and I fear that now when it does come, it will be too late to have any real effect, in view of the model conditions that have now been issued by the Institution of Electrical Engineers.

(2) Electric Lighting Bill, 1914.—Everything has been done to try and get this Bill into Parliament. With this end in view, negotiations were opened up with the Electrical Contractors' Association to try and get them to withdraw their opposition, in order that the Bill might go through unopposed. It was ascertained that many of the contractors were in favour of withdrawing opposition, and at one time it was even understood that this would be done.

Subsequently, however, much to my disappointment, and, I think, of all the members of our Council, the opposition element in the Contractors' Association was successful, probably due to the action of those who are opposed to wiring being carried out by municipal supply authorities under any circumstances whatever.

Let us examine the position which would arise if these powers were obtained and exercised, because I believe the contractors exaggerate the quantity of work that it would be possible for a municipality to undertake. First of all, we seek these powers not for the purpose of securing more trade, but to ensure good work, especially in the cheaper classes of installations. The expensive work in hotels and good-class business houses and residences, which is well paid for, is, as a rule, well done. Moreover, there is the wiring work for telephones and bells which the contractors must obtain, because the municipality has no power to do it and does not seek such powers, with the result that a customer will probably prefer to place the whole order with one person instead of two. In addition, the contractor can calculate the profit on the whole combined order, and he could probably successfully compete in price with the municipality. With the cheaper work, the case is entirely different, the margin of profit is so small that the quality of the work often suffers, and the men who do it, as a rule, are not worth going for if trouble results. It is this jerry work that we want to eliminate.

If we obtain the powers we seek, we shall be able to put to the contractors who are at fault that they must do good work or we will do the work ourselves. There is surely nothing to be alarmed at in this.

The opinion has been expressed that some of the supply engineers are inclined to be unfriendly towards the contractors, and that on this account it would be detrimental to the contractors to agree to wiring being carried out by a supply authority. There may, of course, be under-

takings where things do not run smoothly between the engineer and the contractors, but I venture to think that these are few and far between and should not govern the general policy of an important Association such as that of the contractors.

In any case, I maintain that the idiosyncrasies of a few engineers, and possibly also of a few contractors, should not be allowed to interfere with the well-considered policy of our Association in putting forward a scheme that all supply engineers, and, I venture to believe, all broad-minded contractors, consider to be in the general interests of the industry. Supply engineers, in order to hold their positions, must be good business men, and I cannot imagine a good business man following a policy of opposition and unfriendliness towards the contractors operating in his area. If he does such a thing, I think there is no doubt he would not occupy such a responsible position for any length of time,

I sincerely hope that a satisfactory agreement will be shortly arrived at. It is unthinkable that supply undertakings can do without electrical contractors.

(3) Electric Vehicle Committee.—Considerable progress has been made during the past few months in developing the adoption of the electric battery vehicle in this country. Demonstrations have been made in several towns, and working trials are being arranged for over extended periods. I wish to impress upon members of the Association that it is obviously impossible for the manufacturers of these vehicles themselves to give extended trials in more than a few towns. It is only by bringing and keeping these vehicles before the public that interest will be aroused in them, and for this purpose I consider that supply undertakings should be prepared themselves to bear some of the cost. Demonstration vehicles can quite well be used by municipalities for many of the operations that have to be carried out by them, such as street cleansing, collection of house refuse, conveyance of stores and materials between departments, etc. Money

spent in pioneering work of this kind will, I am convinced, amply repay the supply undertaking. It also gives confidence to the public when they see the vehicles in service, and it enables first-hand figures as to cost of operation to be given to prospective users.

There is no doubt that in a large city many thousands of pounds of revenue will be obtained annually from the use of these vehicles when their adoption becomes general, and the sooner we engineers take pains to push their use, the sooner will our revenues be augmented in the way I have indicated.

I would here like to remind you that, up to the present, the expenses incurred by the Electric Vehicle Committee have been met out of the funds of our Association. The Committee feel, however, that their expenses are likely to increase considerably and that it should not be necessary for them to draw upon the funds of the Association in future.

They estimate that during the coming twelve months their requirements in this respect will amount to about £200, and, with a view to meeting this expenditure, they are approaching the various municipal electric supply undertakings with a request that they should each contribute from one to three guineas towards this fund. They have also approached the manufacturing firms and others interested commercially in the movement, and I am glad to say have been met by a very liberal response.

I put forward for the consideration of the municipalities the suggestion that any contributions they make towards these preliminary expenses of the Electric Vehicle Committee will be ultimately repaid to them many times over when the electric vehicle comes into general use. I therefore have no hesitation in asking for their sympathetic support in the early stages of the movement.

(4) The Industrial Committee of the Institution of Electrical Engineers.—I do not think I shall be committing a breach of etiquette by referring to the dissolution of the Industrial Committee of the Institution of Electrical Engineers. The Report of the Council of the Institution makes it clear that the Industrial Committee felt that under their existing constitution and powers they were not in a position to perform useful work. The Council could not see their way to confer any further powers upon the Committee, and the only thing to do under the circumstances was to dissolve it. The Committee expressed the opinion that :—" An organization should exist which is capable of protecting and promoting the legislative and industrial interests of the industry in so far as these interests are not already represented, protected and promoted by the various existing associations, and also for the purpose of co-ordinating and supporting the work of these sectional associations."

As a member of the now defunct Industrial Committee, I should like to explain to you exactly what was in their minds when they framed this resolution. They recognized that in all industrial concerns, differences of opinion must arise on matters of policy and detail, and the same thing applies to the operations of the various existing associations, which are bound to come into conflict with each other at times. Such points of disagreement are usually settled by meetings and discussions between the associations concerned. Occasionally, however (and I venture to suggest that the present disagreement between us and the Electrical Contractors' Association over the wiring clauses is a case in point), disagreements arise which it appears almost impossible to settle. The Industrial Committee felt that a case of this kind was one in which they should be in a position to assist, and, if necessary, offer to arbitrate, and, in view of their not being able to do this under their constitution, they felt that some body should be called into existence which would be capable of offering its services in such an eventuality.

I am of the opinion that all the associations connected with the electrical industry (and there are many of them) should form from their members a central association, which could arrange conferences to consider disagreements between individual associations, and, if necessary, arbitrate upon the same, and which could be called together by any individual association requiring support in its operations, whether political or industrial. It rests with the various associations themselves to form such a body, and if it is called into existence solely for this specific purpose, there is every reason to believe that it will be of inestimable advantage to all branches of the industry.

It is obvious, I think, that the many and varied interests represented on the Council of the Institution of Electrical Engineers, which interests are largely individual and not really representative of the various associations, render it impossible for the Council to deal with disagreements between individual associations in the way that a body such as I have outlined could.

(5) Combined Control of Municipal Gas and Electric Supply Undertakings.—I do not know whether the members of this Association read the very interesting address given by Mr. J. J. Newbigging in his capacity as President of the Manchester District Institution of Gas Engineers at their annual meeting held in March last. The address was very fully reported in the issue of the "Gas World" dated March 7th, 1914.

The first part of the address deals with technical matters upon which I will not touch, but towards the end of the address, Mr. Newbigging touches upon competition with electricity, and, coming as they do from the chief gas engineer to the Manchester Corporation, his remarks provide ample evidence that gas undertakings are beginning to fear the competition of electricity.

In comparing the electricity and gas undertakings in Manchester, Mr. Newbigging did not refer to the real reason why electricity has been coming to the front so much faster than gas. This is undoubtedly due to the great reduction that has been made in the average price at which electricity is now sold to the consumer as compared with gas. I have not the Manchester figures by me, but a comparison of the Birmingham figures will be interesting.

In the year 1901 the average net price of gas in Birmingham was 26·68d. per thousand cubic feet. In the year 1914 this has dropped to 19·41d. per thousand cubic feet, which is equivalent to a reduction to the consumer of 27·3 per cent. in the average price at which he is charged.

The figures for electricity are as follows. In 1901 the average price received per unit was 4·37d. In 1914 this has dropped to 1·15d., a reduction of 73·6 per cent. in the price charged to the consumer.

Here we have the real reason why gas is beginning to feel competition with electricity.

Mr. Newbigging makes some interesting suggestions by which gas undertakings could improve their position.

He suggests supplying gas engines on hire-purchase terms ; this, I believe, has already been tried by some undertakings, and in this city at least it was discontinued.

He also emphasizes the point that the gas distributed should be absolutely regular in composition and be maintained at a constant and minimum pressure available to every consumer. The composition of gas distributed is, I believe, generally maintained satisfactorily, but the pressure at which it is supplied to consumers undoubtedly varies between very large limits in the outlying parts of a city, where it is used for lighting and where a constant

pressure is most important. If competition with electricity will have the effect of making gas engineers recognize their responsibility in this direction, I am sure that even gas consumers will bless the introduction of electricity.

Another suggestion that Mr. Newbigging makes is that a competent staff of highly trained fitters should be established to clean consumers' burners free of charge and supply mantle renewals at cost price. Now if an organization of this kind is to be developed capable of dealing with many thousands of consumers, it must mean a very heavy expense on the undertaking. The idea suggested to the lay mind is that gas burners must be very unsatisfactory pieces of apparatus if they require frequent attention by highly trained fitters to keep them in proper order. Here, again, the gas consumers ought to be obliged to the competition of electricity for compelling the gas undertakings to look after their interests better than has been done in the past.

Mr. Newbigging then goes on to suggest a combined control for municipal gas and electricity undertakings. I am glad to have this opportunity of joining issue with him at once.

I was under the impression that when the question of combined control was raised early in 1911 between the gas and electricity committees of the Manchester Corporation, it was decided that the two committees should remain separate. The same question was discussed in Birmingham about the same time with a like result. I am therefore very surprised to see Mr. Newbigging raising the point again in his address.

I will briefly state the arguments he puts forward in support of his suggestion, and criticize them.

He says :—

(1) That municipally-owned undertakings stand on an entirely different plane from company controlled undertakings, and should be administered accordingly.

(2) That there can be no doubt that the existing methods of separate administration and management are neither conducive to economy nor satisfactory to the consumer, and that reforms could be easily introduced which would tend to the lowering of the selling price of their products.

(3) That gas undertakings work to a fixed rate of charges, while in many electrical undertakings the price of current was sometimes cut down to an unjustifiable figure to secure business.

(4) The obvious remedy was that the two departments should be merged into one under the supreme control of one Committee which would, if it were composed of broadminded and commonsense men, conduct the business in the interests of the consumers.

(5) That competition would not be stifled, but the contrary would be the case, as this closer connection would tend to foster keen rivalry between the two technical departments to produce both gas and electricity at the least possible cost.

I am of the opinion that the single control of gas and electricity undertakings would have exactly the opposite effect to that outlined by Mr. Newbigging. It would mean the total suppression of competition, and would create what I consider would be fatal to the interests of the consumer, namely, collusion. Instead of tending to foster keen rivalry between the two departments, I am convinced that it would effectually destroy that desire amongst the staff to improve upon previous records that is such an immense factor in the success of these public supply undertakings. Fair competition must always have a stimulating effect on industrial concerns, and to stifle this would be to deprive the ratepayer of the only real guarantee that he has for the most economical administration of both departments.

The charge that prices for current were sometimes cut down to an unjustifiable figure to secure business cannot be substantiated.

The sale of gas is largely controlled by the amount the undertaking can obtain for its by-products. This amount is frequently greater than the gross profits earned during the year.

The electricity department has no by-products to sell except the useful employment during the hours of small

demand of the generating plant and underground distributing mains, which have been purchased to supply the maximum load demanded during the winter months, that is, cheap current with a high load factor, and low quotations for current of high load factor are perfectly justifiable under these conditions, They are not given with the sole object of securing business, but to reduce the average cost of giving the supply, to the benefit of the whole of the consumers.

I maintain that it would be impossible for one manager and one Committee to work both departments in the interests of both classes of consumers. A man must become biassed to a certain extent in favour of one or other of the branches of the supply, and it would be practically impossible for him to give an unbiassed recommendation to his Committee on a point involving, for instance, the development of some new area, as to whether this should be carried out by gas or electricity.

Consumers would resent being told that they could only have one or the other, and such a policy would undoubtedly have the effect of driving manufacturers and others away from the city, whilst it is more than likely that the Board of Trade would be inclined to admit outside competition from power companies if they found that the statutory obligations for giving a supply were not being properly carried out.

To my mind there is no evidence whatever that the existing methods of separate control of both gas and electricity undertakings have been unsuccessful. There is a field for both of them, as is shown by the increased outputs of both that are recorded year by year, and until such evidence is available, single control should not be considered.

There is another point that is affected by this suggestion of Mr. Newbigging and which he has evidently never considered at all, and that is the centralization of electric supply undertakings in this country, about which I want to say a few words to you.

If centralization ever comes, and I feel that it would be greatly to the advantage of the users that it should, it is obvious that it would be quite impossible to arrange for single control of two industries, one of which was purely local and limited to comparatively small and isolated areas, whilst the other was national and capable of being applied over the whole of Great Britain as one concrete system of supply.

So much for single control—I will now discuss centralization.

Signs have not been wanting for some years past that the question of bringing isolated electric supply undertakings under one central system of supply has been occupying the attention of electrical engineers. Especially has this been the case in London, where attempts have been made to amalgamate the various companies operating in that area by the formation of a central supply company. More recently the London County Council has been making very exhaustive inquiries into the same subject, and there is reason to believe is strongly in favour of centralization of all the supplies, whether company or municipal. In the provinces, too, the larger municipalities have been extending their boundaries, and incidentally taking over the electric supply undertakings belonging to the areas incorporated, with distinctly beneficial results to themselves and to the areas taken over.

Parliament has also recognized the principle by agreeing to the formation of the various power supply companies which are operating in several counties.

All these instances are steps in the right direction, though we are as yet a long way off the goal—where it will be possible to obtain, all over the country and at one rock-bottom price, a supply of electrical energy for any purpose, such as power, heating, lighting (and this will ultimately be such a small percentage of the whole that the poor load factor can be safely ignored), domestic requirements, traction by rail, road, or tramway, etc.

We are a nation of manufacturers, and to a large extent every inhabitant of this island is dependent upon our maintaining our position in the markets of the world. Our manufactories can only hold their own in these markets if they can produce as cheaply as possible, and one most important consideration towards this end is the provision of cheap power and cheap transit for both goods and workmen.

Other countries are recognizing this; America and Germany, our two greatest trade rivals, are establishing centrally controlled systems of supply, which cannot fail to have a far-reaching effect upon their commercial welfare.

We must do the same unless we are content to take a back seat in the future.

The larger municipalities in this country, such as Glasgow, Manchester, Birmingham, Liverpool, Leeds, etc., have pointed the way—now it remains for Parliament to tackle the question of nationalization; whether by means of a Government Department or a Public Board of Management, such as the Port of London Authority, or a private company, subject to limitations as to dividends and prices to be charged for current supplied, is yet to be seen.

Until some such scheme is brought into operation, it is useless to expect any marked reduction in the cost of producing and distributing electrical energy below that obtaining in the large power stations now operating in this country. It is only by tackling the problem boldly, by being prepared to supply current at prices much lower than are ruling at present, and recognizing that for a few years there must necessarily be a deficit on the large initial expenditure incurred, that it will be possible to attract and develop the large volume of business that will be necessary to make such a scheme a financial success in the future.

It will be as necessary to face expenditure in pioneering work for this scheme as it was in the early days of electric

lighting, with this difference, however, that the returns to be expected should come very much sooner. If such a policy is ever decided upon, it must be strictly adhered to, and it should incorporate the following outlines.

Large bulk supply power stations should be installed in various parts of the country having regard to the three following chief requirements :—

Proximity of an ample quantity of coal.
Proximity of an unlimited supply of water for condensing purposes.
Proximity of the various large centres of industry where the major portion of the energy is likely to be required.

Railways, of course, cover practically the whole of the country, so that these can be fed economically at any point or points throughout their length.

As soon as these bulk supply stations are available and the distributing trunk cables installed, the majority of the small generating stations in the country should be at once shut down and utilized as sub-stations.

It would probably be found most satisfactory to, in many cases, adhere to the existing methods of distribution, and to utilize these as far as they will serve, possibly, as they become filled up, installing alongside of them other schemes for distribution of energy which may prove more economical to handle.

And now a word about the engineers who are at present in charge of these isolated supply stations. It will probably be concluded that when all these stations are shut down the engineers in charge of them will not be required, and it is only human nature to resist the formation of such a scheme from the fear of being thrown out of employment.

I consider that it would be the worst possible form of so-called economy to dispense with the services of a single man that is at present employed in all these undertakings. The very object of the scheme is to enormously increase

the business to be handled in all these centres by giving the supply at a much more attractive price. The men on the spot have the best knowledge obtainable for pushing the business and developing the distribution of the bulk supply that they would receive, and the chief engineers in charge would be especially valuable in this direction. We electrical engineers have to be managers of our businesses as well as engineers in charge, and the business control is every bit as important as is the engineering control. The commercial side of the business is so dependent upon technical matters that it is necessary to have an engineer at the head. I do not see, therefore, that there need be any apprehension in the minds of the existing engineers in charge that they will not be required if such a scheme comes into being.

The main distribution should be carried out wherever possible by means of overhead trunk mains, and provision should be made for reasonable wayleaves to be compulsorily granted. Without special powers regulating the granting of wayleaves, it is probable that the cost of obtaining them would very nearly kill the saving of overhead trunk lines compared with underground cables.

Another great advantage of the scheme would be that the cast-iron boundaries of existing municipalities and companies, which at present limit the various areas of supply, would entirely disappear, with the result that development could go on freely and along lines most beneficial to the community in general.

London is now considering working out its own salvation on lines such as I have suggested, and it will be a great pity if the scheme that is finally adopted is not so laid out that it will be possible to work it in as part of a large national scheme such as I have indicated. There is no reason why the London scheme should not be considered from this point of view and developed along these lines.

Now as to how such a scheme should be inaugurated.

It is pretty evident that Parliament has its hands so full that there is not much hope, for the present at all events, of any move being made in this direction. I suggest, however, as this scheme is so vitally important to all industrial centres, that in their own interests the large municipalities, who at present control the major portion of the bulk supplies in the provinces, should meet together and discuss the matter, and, if possible, formulate a satisfactory scheme which could then be brought jointly before Parliament to be subsequently developed on proper commercial lines.

In my opinion, this method of procedure is the most suitable one to adopt, and the justification for it is:

The supply of electrical energy for all purposes, whether industrial, domestic, or public utility, at a price far below what is now being paid:

(*a*) For the benefit of the community as a whole.

(*b*) For enabling our manufacturers to compete successfully with their rivals abroad, who, it must be remembered, are developing their resources on these very lines.

(*c*) For the abolition of smoke in our large cities, and the consequent general improvement in the health of the community.

(*d*) For the conservation of our coal supplies, which will be utilized on the most economical lines at present known to science, and

(*e*) For the upholding of our position as the leading country in the world of commerce, which position is being assailed more and more every year.

These reasons should surely be sufficient to make the controllers of our large industrial communities look carefully into the question of centralization of the supply of electrical energy.

Vote of thanks to the President.

Alderman Bruce (Sunderland), in proposing a vote of thanks, said they were all very much indebted for the matter contained in the Presidential address. It could be considered later on in detail, and he was sure that it would help in their deliberations and discussions in the future. It contained a very wide and thoughtful summary of the work of the Council, and dealt with the various matters which the Association had so much at heart. There were differences of opinion on some of these, and therefore the Presidential address would be a very valuable help, as it touched upon the points now before the country in a very practical manner, and referred to both sides of the question.

Mr. H. Richardson (Chief Electrical Engineer, Dundee), seconded the vote of thanks to the President for his able and up-to-date resumé of so many matters vitally affecting the interests of the Association.

The vote of thanks was carried by acclamation.

SOME NOTES ON

The Commercial Development of Electricity Supply in Moderate-sized Towns.

By W. A. VIGNOLES.

Chief Electrical Engineer of the Corporation of Grimsby.

Introductory.

ALTHOUGH it is beginning to be generally recognised that the supply of electricity is a commercial proposition and a number of managers are developing their undertakings on commercial lines, endeavouring to sell electricity as they would any other commodity, there are still undertakings where the commercial spirit is not as much in evidence as it should be.

For this reason, and because the prosperity of all undertakings will depend sooner or later on their proper commercial organisation, this question cannot be discussed too often, as undoubtedly such discussions and a free interchange of views stimulate ideas and prevent stagnation.

The writer, therefore, offers these few notes, not with the idea that he has anything particularly new to say, but rather to provide a peg upon which a discussion of this most important subject may be conveniently hung.

Scope of Paper.

It is proposed to discuss the problems to be met with in the supply of electricity in towns of about 100,000 inhabitants, and the conclusions reached will naturally be based on the writer's experience in his own town, Grimsby. This town has a population of about 77,000 inhabitants. There are docks and a large fish market, the largest in the world as a matter of fact; there is a large export trade in coal, while timber and general merchanise are imported. Factories are few in number, though there are the usual miscellaneous workshops incidental to a shipping town, and a few large sawmills. The latter, however, usually employ steam for power raising, burning their wood refuse instead of coal.

Grimsby has no special powers for selling apparatus to consumers.

Something to Sell.

In the business of electricity supply the first essential is to realise that there is something to sell, and the second, that to be successful in that business we must, in selling slang, "deliver the goods."

What is being sold is not electrical energy; electrical energy is not wanted for itself, but only for conversion to light, power or heat.

In approaching consumers we should avoid as far as possible talking about volts, amperes, units, or using other

technical terms until the consumer has been taught what they mean, and then only if it is absolutely necessary to employ them.

It is better to talk about what can be done with the energy; the amount of light that can be obtained for the expenditure of a given sum of money; or the amount of power, in the latter case using the term "horse-power," an expression familiar to all power users.

Publicity.

To market the commodity it must be brought to the notice of the people who are likely to buy it, and this may be done in any of the ways shown below, all of which come under the general heading of publicity.

(1) Showrooms, where electric fittings, heaters and cookers can be seen in use.
(2) Periodical exhibitions or demonstrations serving the same purpose.
(3) Advertising.
(4) Personal canvassing.

If the undertaking has powers to do installation work, then a showroom is undoubtedly a useful, and some managers think, the best method of getting into touch with the consumer, while the cost can, to a large extent, be borne by the profit on the Installation Department.

Where, as in Grimsby, the undertaking has no special powers, and arrangements have to be made to sell through contractors, only a small proportion of the cost can be covered by the profit on sales, and the writer is convinced that under these circumstances the same results can be obtained in other ways at less expense. This view is based on experience of temporary showrooms, and on the figures that have been given to the writer for showrooms in other towns; for instance, the engineer in a town of about 100,000 inhabitants stated recently that his showroom cost him £600 per annum excluding canvassing staff; in Grimsby

excellent results have been obtained by advertising with considerably less expenditure, as the following figures will show.

Year.	1908–9.	1909–10.	1910–11.	1911–12.	1912–13.	1913–14.
Amount spent in Advertising	£20	£48	£177	£335*	£268	£250
Increase in Private Consumers	102	106	203	168	230	315
Increase in Lamps connected for Private Consumers	6,818	7,396	13,949	14,241	15,180	17,714
Increase in h.p. of Motors connected ..	98	52	233	202	248	316
Increase in Revenue from Supply to Private Consumers only	£38	£869	£1,242	£1,062	£1,864	£2,144
Increase in Connections, Heating and Cooking, equivalent 8 c.p. ..	—	750	719	3,147	2,173	3,411

* This includes nearly £100 spent on demonstrations, exhibitions, and showrooms.

Advertising.

It is not proposed to deal exhaustively with the value of different classes of advertising as time will not permit, but a few notes may be of interest.*

All of the following methods are used.

(1) Advertisements in local newspapers.
(2) Enamelled iron plates on works using power.
(3) Enamelled iron plates on the lamp posts in the streets.
(4) Posters in selected positions on Corporation property.
(5) Personal facsimile letters.
(6) Church and chapel magazines, and bazaar catalogues.
(7) Exhibitions and demonstrations.
(8) Pamphlets and leaflets.

* See also some articles contributed by the author to Electrical Industries, in December, 1912.

(9) Issue of two localised magazines—*Electrics* and *The Unit*—advertising electricity for works and for the home respectively.
(10) Loaning apparatus for trial.
(11) Canvassing.
(12) Issue of a Consumers' Guide.

On a turnover of £20,000 to £24,000 the cost, which has averaged about £250 per annum, cannot be considered extravagant.

Greater publicity is, however. required in all towns, and many managers of electricity undertakings are viewing with envious eyes the activities of the British Commercial Gas Association. This Association must be spending thousands of pounds on their publicity campaign, and with the immense amount of capital now invested in electricity undertakings, and the proofs that are continually being brought forward that advertising does pay, it is surely time that the electric supply industry should combine together to make some effort to place the merits of electricity supply before the country in a forcible manner.

The Electric Supply Publicity Committee has done a certain amount of work in this direction, but owing to lack of funds or to some other reason, it has not done much more outside London than supply leaflets and advertising literature to local undertakings.

The writer suggests that the I.M.E.A. should appoint a Committee with full powers to confer with the Electricity Supply Publicity Committee or any other body, to endeavour to formulate some scheme by which a co-operative system of publicity could be put on foot for the benefit of electricity supply generally.

One obstacle to combined action is that it is difficult to convince Committees and Councils that expenditure on advertising is not so much money wasted, while a good many station engineers do not appreciate the value of, or see the necessity for, sustained publicity work. The writer would

ask these engineers and all members of Committees represented at the Convention to make enquiries in any town where a sustained publicity campaign has been maintained ; he is quite sure that, provided the prices at which electricity is being sold in such towns are reasonable, the replies will show the great benefit of publicity work.

Another difficulty that has been pointed out is that, where the accounts of Local Authorities are subject to Local Government Board audit, objections have been raised to the spending of money on advertising. A recent ruling of the Board, however, is to the effect that advertising literature may be purchased, but that authorities have no power to subscribe to the funds of an Association organised on the lines of the Commercial Gas Association. A different constitution might get over the difficulty ; if not, the sooner the I.M.E.A. Electricity Bill, in which there is a clause dealing with this question, is passed the better.

Cases where Electricity and Gas are both Supplied by the Corporation.

Perhaps a further difficulty in the way of a large combined municipal scheme of advertising, is that in a number of towns both electricity and gas are in the hands of the Corporation and that Committees and Councils are afraid that an energetic policy in connection with the electricity undertaking may injure the gas supply. This fear is without foundation, as there does not appear to be any gas undertaking in the country that has seriously suffered from the competition of even the most energetic Electricity Supply Authority ; in Grimsby the Company continue to pay 10 per cent. dividends and in the last few years has spent a considerable amount of capital in reorganising their plant. The fact is that the standard of illumination has been raised considerably owing to the competition between electricity and gas, while power is now used in many trades that were at one time content to employ hand labour only.

An energetic policy and an advertising campaign on the part of both undertakings will not hurt either, but will be for the benefit of the consumer as it will keep before him all the uses to which electricity or gas can be put, while the competition will keep both Departments alive and up to date. A Corporation that instructs the management of the two undertakings to confer together, with a view to keeping prices above a competitive level, is not doing its duty by its consumers or by its ratepayers.

Exhibitions.

Exhibitions and demonstrations are very useful in stimulating interest and should be held from time to time, especially when any development comes along that it is desired to bring to the notice of the public ; but the cost is heavy and they should not be held too frequently, otherwise the appeal is likely to lose its force.

Great interest was shown in some cooking demonstrations held in Grimsby a year or two ago, the apparatus being shown in a General Trades Exhibition, and demonstrations given by a lady teacher of cookery well known in the town.

The manager also lent a hand from time to time showing how the " mere man " could, with the aid of an electric cooker, turn out delicious omelettes.

These demonstrations did a great deal of good, and resulted in a number of orders for electric light as well as the placing of cookers.

Canvassing.

Every undertaking of the size under consideration should employ an Engineer as canvasser or representative, devoting the whole of his time to following up enquiries and canvassing. If systematic advertising is carried out it will be found that one man will be fully employed in following up enquiries and in endeavouring to secure consumers where

it is proposed to lay extensions of mains, and will have little time to devote to house-to-house work. He will probably require assistance from time to time in carrying this out, and a junior can be usefully employed on this, and so trained for more responsible work in the publicity department.

The canvasser should have a special aptitude for commercial work, but must have a good knowledge of the applications of electricity, and should be able to advise the consumer on general lines in accordance with the manager's views.

He should send through a daily list of his calls, and should report personally in any cases where he has difficulty in securing the business; in these cases the manager should visit the possible consumer, even if the installation in question is only a small one. Such a visit is always appreciated as the consumer feels that he is important enough for the Chief of the Department to take a personal interest in him, and many a waverer may be secured by a timely call of this kind.

With large power consumers the personal efforts of the manager will nearly always be necessary before the business is settled.

Arrangements should be made with the Borough Surveyor to supply the Department with the names of persons who have submitted building plans for approval, and to give particulars of any new roads or estates that are being laid out; a good deal of early and useful information can also be obtained by the canvasser maintaining friendly relations with the various house agents in the district.

Strenuous efforts should be made to induce the speculative and other builders to wire new houses; it will be found that an advertising campaign is of assistance in this connection as it educates the public, and reminds people who are looking for a new house to ask for one that is wired for electricity.

How to Satisfy the Consumer.

Two essentials are necessary in order to satisfy a consumer or "to deliver the goods."

(*a*) The goods must be right.
(*b*) The price must not be excessive.

Taking the first proposition, the consumer must get what he wants. Where the undertaking carries out the installation it is easy to ensure this, and is, I think, one of the best arguments in favour of the undertakers being granted full wiring powers. It must also be easier to get a possible consumer to finally make up his mind if it is possible to quote him a price for his installation, than if the consumer has to make enquiry from a contractor, as the latter may have different ideas on the question of what the consumer should have, and this may delay the completion of the negotiations. This difficulty has occurred very frequently in Grimsby, and great trouble has also been experienced at times in getting contractors to follow up enquiries that have been obtained.

Free Advice to Consumers.

To get over these difficulties the Department offers free advice to all consumers, and for a small fee, 2½ per cent. on the value of the work with a minimum of 5s., undertakes the preparation of a specification of what is required, and superintends the carrying out of the work.

Alternatively, any consumer can obtain free of charge an outline scheme for the lighting of his premises.

These schemes and specifications are prepared under the manager's supervision by a special assistant (who may be called the consumer's engineer) well up in illumination problems, and are worked out on scientific lines.

These facilities have been much appreciated, and an increasing number of consumers are taking advantage of them, with the result that there is a marked improvement

in the methods of illumination in recent installations, and consumers are in consequence better satisfied. In the same way schemes are prepared for power users, but these are fewer in number and are usually worked out by the manager or the chief assistant.

Complaints.

Equal care is taken to satisfy the consumer after he has commenced to take a supply, and all complaints as to lights being out, due to fuses blowing, or other cause, are recorded by means of a special complaint form shown below.

CORPORATION ELECTRICITY WORKS, GRIMSBY.

Date .....

Time .....

Complaint Form issued by

Form sent to .....

Complaint from .....

Address .....

Nature of fault .....

.....

.....

Attended to by .....

Report the cause for complaint and how fault was rectified.....

.....

.....

.....

Left all correct at.....

This matter has been reported to me, and I have to say.....

.....

.....

.....

Signed,

Date.....Time.....

Noted by Chief Engineer. Noted by Head of Department.

.....

The actual complaint is attended to by a junior, but the principle adopted is that the form is afterwards scrutinised by someone more responsible, with a view to determining if the trouble has really been located and corrected.

If anything further has to be done a "follow-up" form is issued, *e.g.* in cases where the consumer is told to get a contractor to remedy a defect. This form insures the matter being kept in sight until the defect has been finally put right.

These forms are filed after a note has been made of the date of the complaint in a card index in which each consumer is represented by a special card.

This may seem a somewhat elaborate system, but it has frequently proved its value, as a record is obtained of everything done by the staff on the consumer's premises, while an abnormal number of complaints from any installation is at once noted; in several cases of complaints by contractors as to the way the youth sent had dealt with the matter, it has been possible by means of these reports to show conclusively that the trouble had been properly attended to.

Pushing New Devices.

When new devices or apparatus are placed on the market, the Department purchases a few examples and lets consumers have them on loan for trial.

The consumers' engineer usually deals with these matters, and when the apparatus is on circuit looks after it until satisfaction is obtained, and endeavours finally to effect a sale through a contractor.

The Price.

The price charged for " the goods " supplied must be such that the consumer is satisfied ; he must feel that taking everything into consideration the article offered is worth the price asked.

Anyone can sell a good article if it is offered at a lower price than a bad one, but with good salesmanship it should be possible to get more for the good article than the inferior one ; in other words, electricity being (as is well known) superior to gas, it is possible to get consumers to pay more for it. There is a limit, however, and unless the price is at such a level that the consumer is satisfied, no amount of advertising, canvassing, or pushing will create permanent business.

The writer remembers entering a provincial showroom a year or two ago ; heating apparatus was on view, the tables were loaded with pamphlets, and he was told that a considerable sum had been spent in pushing heating, but with indifferent results.

On inquiring the price he was told it was $2\frac{1}{4}$d. per unit ; it is needless to add that the staff in the showroom were very half-hearted as to the possibilities of this branch of electricity supply.

Hire Department.

Some years ago the Grimsby Electricity Committee met the local contractors, and after discussing the question of hiring with them, a friendly arrangement was come to by which the Department hires out :—

(1) Motors and starting apparatus.
(2) Arc lamps.
(3) Cookers.
(4) Heaters, and
(5) Provides installations and apparatus on hire purchase.

All wiring work is done through a contractor and no apparatus is hired out that is of less value than £3 10s.

In many cases the Department takes over the hire purchase of apparatus or installations provided and arranged for by contractors. This is a great convenience to contractors who make a sale without having to finance a hire-purchase scheme. In these cases the profit is shared between the contractor and the Department.

It is interesting to note that whereas in the early stages of the development of the power load, four-fifths of the motors were on hire, now by far the larger number of motors that are connected up each year are purchased outright from contractors in the town.

It is of the greatest importance that consumers should be induced to adopt electricity for all purposes, and everything possible should be done to make it easy for them to do this by the hire, supply on hire-purchase, or loan for trial of all kinds of apparatus ; at the same time if the contractor can be kept interested he will be able to make direct sales as the consumers obtain confidence, and the Department will, at no cost, obtain the services of a number of canvassers. In fact, the Department should encourage and work with the contractors as far as possible.

No doubt many engineers will differ very strongly from the views expressed above, and will say that they have tried working with the contractors and that it is hopeless. No doubt it is difficult at times, there are bound to be difficulties, as the contractors are quite independent of the Department, and, naturally, have their own views which will not always coincide with the views of the manager. With goodwill on both sides, and with the exercise of tact on the part of the manager, these difficulties can be overcome, but only if the latter is able to sympathise with the special difficulties which the contractor has to meet.

Many of the towns that have their own installation department, showrooms, etc., have made wonderful progress, for example, Norwich ; but it is a question if these undertakings under the same management would not have made a good showing even if they had been without an installation department. Probably in each case "a way" would have been found.

Rental Wiring.

It must also not be overlooked that one of the principal reasons for the rapid development at Norwich is that installations are provided if required on a rental basis, and undoubtedly all towns should be in a position to give this facility. But this can be given equally well by placing the actual work in the hands of a contractor, the Corporation merely doing the financing.

In connection with rental wiring it is advisable to combine the charge for the hire of the wiring with the fixed charge of the rateable value system if electricity is supplied on this basis. In such a case the consumer pays a fixed sum per annum which includes the cost of the wiring of his premises and the capital charges for electricity supply, and the only additional payment he has to meet is the cost of current at the running rate of 1d., or ½d., per unit, as the case may be.

Sales Department not Essential.

Sufficient has almost been said to show that it is possible to adopt a forward policy and to successfully develop the business of an undertaking without the help of a sales department. No manager need sit down with folded hands and say, "I cannot adopt progressive methods to develop the business because I have no powers to institute a sales department."

Extensions of Mains.

If an undertaking is to progress satisfactorily there must be no hesitation on the part of the Committee in spending the money required for extensions of mains to reach consumers. All undertakings have powers to ask new consumers, apart from those in certain scheduled streets, to guarantee to consume electricity to a definite amount, usually to the value of 20 per cent. on the capital outlay involved in laying any new mains required; if the district in which the consumer requires supply is such that it does not seem possible that other consumers will be supplied, it may be policy to ask for such a guarantee if there is any doubt that the consumption will reach the required amount. Many consumers, however, are very strongly opposed to giving any guarantees, although they are prepared to pay for any electricity they use at current rates, and if the probabilities are that the consumption will be greater than the amount that can be asked, there is really no object in obtaining an agreement, and insistence on it may cause the loss of the business. In new streets guarantees should certainly not be asked for, but mains laid as a matter of course before the houses are built.

Broadly, the principle might be stated to be, that a guarantee should not be asked for unless there is a strong probability of the undertaking losing money by giving the supply and it is felt that it would be better to be without the consumer; but in coming to a decision the possible developments in the next few years should be borne in mind.

This question has been forcibly brought home to the writer by the fact that in the past a number of consumers have been lost by asking for guarantees, and a few years afterwards mains have actually had to be laid down past the premises where supply had been wanted.

The fixing of the size of the distributor to be laid is a very important matter; two errors may be committed, one in

laying the distributor too large at first, making the extensions very expensive, and the second in laying too small a cable which may cause trouble later on by drop in pressure. There is very little probability of the mains being overloaded from the point of view of temperature, as with paper insulated lead covered cable the current which can be dealt with on small mains without risk of damage is exceedingly high. In Grimsby a very large length of $\frac{7}{1\,6}$ 3-core distributor has been laid and has given excellent results in providing for extensions in streets where there are numbers of small houses. With a cable of this size laid on each side of the road a heavy current can be dealt with, though the writer's present practice is to run one cable of this size in the first instance and if additional consumers are obtained, to lay a $\frac{1\,9}{1\,6}$ cable on the other side of the road. With this arrangement it is not anticipated that there will be any trouble even if a considerable proportion of the consumers use electricity for cooking and heating purposes.

Future Developments.

The supply for lighting is becoming each year a smaller proportion of the business, owing to the development of the uses of electricity for other purposes; and if the half-watt lamp is developed in small sizes the sale of electricity for lighting will receive a check.

The development of this lamp has been received with alarm by some engineers, but the same alarm was felt when the metal filament lamp was introduced.

Certainly at that time some undertakings received a temporary set-back, but when one sees in the electrical papers week after week and from town after town, the notices for new plant required, usually large turbines, one realises that the metal filament lamp has very clearly proved

itself a blessing in disguise ; the present prosperous condition of electrical undertakings is entirely founded, as far as the lighting branch is concerned, on the metal filament lamp.

The only way in which the half-watt lamp could hurt undertakings would be if it was introduced in such sizes and at so low a price that it could be generally used for the smallest houses. If this came to pass, the question which is already agitating many managers, as to how to ensure sufficient revenue from small houses to pay the capital charges on the cost of the service, in addition to the cost of current, would become more acute. Except in this way the half-watt lamp cannot adversely affect undertakings, as the decrease in units sold will be accompanied by a corresponding reduction in the maximum demand, and any loss of revenue will be made up by new business.

Public Lighting.

There is a large source of revenue in public lighting which has not yet been tapped in many towns. The perfecting of the metal filament lamp has made it possible to light the streets by electricity at the same price as this work can be done with gas. In Grimsby about 660 lamps of the metal filament type are now in use, and there is a very substantial margin of profit after providing for all capital charges on the mains, posts, lamps, etc., at the rate of 12 per cent. per annum, and charging the electricity used at 1d. per unit. Capital charges are allowed for in this way, but in practice, all capital expenditure for this purpose is provided out of revenue so that the interest on the money is saved.

The Problem of the Small Consumer.

In Grimsby supply is being given to consumers at present whose annual bill only just reaches 30s., while with slot meters many consumers are paying less than this. With

such a small revenue it is extremely difficult to meet all charges. The matter can be dealt with in two ways, the first by reducing the cost of the service; the second by trying to convert the small consumer into a large consumer by inducing him to take supplies for other purpose than light.

By standardization and by adopting a system of looping services, running one cable for each pair of houses, the average cost per service has been steadily reduced from £3 19s. 10d. in 1906–7 to £2 17s. in 1912–13.

Suitable methods and rates of charging must be adopted to induce consumers to generally adopt electricity for heating, and in the writer's opinion the most suitable method will be found to be the rateable value or Norwich system with the running charge not above ½d. per unit.

It is not proposed to discuss the various alternatives to the Norwich system, as Mr. Bowden is reading a special paper on "Systems of Charging" when the whole question will no doubt be fully considered.

Slot Meters.

With the smallest consumers and in premises where the tenant is likely to change frequently, it is very desirable to use slot meters; the revenue that has been obtained in Grimsby from these in the last few years has been as follows:—

	£	s.	d.
Year ending March, 1914	383	8	3
,, ,, 1913	270	3	0
,, ,, 1912	201	8	2

In order to keep in touch with the consumer the meters have been arranged for 5d. per unit, but when the meter is cleared 2d. in every 1s. is returned so that the nett cost is about 4d. per unit instead of 3¾d., the usual flat rate. Meter rents are not charged, so a small consumer pays no more on this system than he would on the ordinary rate.

The system of refunding a proportion of the money put in is popular, as the meter in a way acts as a savings bank, and, in fact, it is strongly suspected that the "man" has to provide the 1s. while the lady of the house draws the rebate when the collector comes round.

Heating.

With the selection of a suitable tariff, the development of supply for heating will go ahead very rapidly. In several of the towns where the ½d. rate is in force, notably Southampton, the units sold run into big figures, and as the apparatus is comparatively cheap, there is undoubtedly an immediate future for this branch of supply.

In Grimsby with a 1d. rate, and without any appreciable number of heaters being let on hire the sales for heating and cooking have amounted to :—

	£	s.	d.
Year ending March, 1912	206	0	0
,, ,, 1913	294	0	0
,, ,, 1914	324	0	0

This shows what can be done on a 1d. scale ; it is anticipated that with the proposed rateable value system, 15 per cent. and ½d., that a very large development will take place, especially as the various types of "heaters," notably the class using red hot elements, are being rapidly improved.

It is hoped to induce consumers to purchase their own apparatus, if not outright at least on a short hire-purchase basis.

Cooking.

Cooking while quite as satisfactory a proposition as electrical heating, suffers at present under the disadvantage that the only suitable apparatus is too expensive for the

small householder to buy, while it is difficult to get consumers to pay 15s. per quarter for cooking apparatus when they can hire a gas cooker for 3s. 6d.

It will be interesting to hear the result of Mr. Seabrook's experiment to charge 3s. 6d. per quarter rent and to add ¼d. per unit to the price of electricity used through cookers on hire, this ¼d. being credited to the hire account.

Undoubtedly, the problem must be seriously tackled, and Mr. Seabrook's plan seems to be very simple and practical, as is usual with most of his suggestions.

One of the difficulties that the manufacturer of electrical cooking apparatus has to contend with at present is that the market he has to cater for is, comparatively speaking, a small one, and consequently he is putting apparatus through his shops in dozens instead of in hundreds. No one undertaking can at the present time order apparatus in large quantities, but if a number of undertakings were to combine together and adopt a particular make of cooker they should be able to buy on better terms.

The writer is not sure if this has been tried in the past, and he hesitates to recommend that the I.M.E.A. should appoint another Committee on this question, although his own opinion is that this Association should have a number of permanent Sub-Committees, each dealing with and fostering the development of some particular branch of electricity supply.

After all, a precedent is to be found in the establishment of the Committee on electrical vehicles which appears to be doing very sound work, work which could not possibly be done by any single undertaking; the question of the appointment of a similar Committee on electric cooking might therefore be discussed.

The first steps in every new enterprise are the most difficult, and the placing of the first twenty cookers in any town will entail a considerable amount of work.

In dealing with this matter it is essential that one or more of the staff should be able to advise on the use of the apparatus, and in order to be able to do this they should actually use the cookers and study the art of cooking in a general way.

When consumers are satisfied with the apparatus and the price charged for the supply, the lines for development can be decided upon.

A lady should then be appointed to take special charge of this Department and to advise consumers on the use of the apparatus. This lady, who should be an expert cook, might also make a study of the general uses of electricity so as to be in a position to help with canvassing by interviewing " the lady of the house," who, after all, is generally the person who has most say on the question of the installation of electricity in the home.

Electric Vehicles.

A large revenue will ultimately be obtained from the charging of electric vehicles. With the good main roads that run all over the United Kingdom, the British motorist who motors for pleasure will probably continue to use the internal combustion engine as being the most suitable for long distance work. In America and other countries, where main roads are non-existent or, at most, tracks, the motorist does not go so far afield, and an electric runabout may answer his requirements. It has been shown, however, that there is a large field in this country for the employment of electric vehicles for commercial purposes, and every supply undertaking should help in the development of this business by providing charging facilities and selling at suitable prices

PART II.—FINANCIAL CONTROL.

Business-getting has been dealt with first, as being the most important factor in the commercial development of an undertaking. But the business having been obtained the next point to be considered is the financial management.

Financial Control should be in the Hands of the General Manager.

The only sound and businesslike policy is to place the whole control of the undertaking, business-getting, engineering and finance, under one supreme head, whatever title he may be given, who shall be absolutely responsible to the Committee for the success of the undertaking. This policy has been adopted in a number of towns both small and large; in these cases the Department is entirely self-contained, the books are kept, accounts collected, and balance sheet prepared by a staff supervised by an accountant under the control of the manager.

In towns where a large part of this work is done in the Borough Treasurer's Department many difficulties occur, because the clerical staff is not in close touch with the facts and details of the working of the undertaking. The writer is informed by many managers, that they have great difficulty in getting figures and statistics at the time, and in the form, in which they want them; this must be a serious handicap, and in one case it was proposed to get over the difficulty by keeping duplicates of a number of the books.

Where the Borough Treasurer controls the finances he naturally exercises a considerable influence in the financial management, but as he is responsible for the whole finances of the city, he frequently is more interested in devising means for keeping down the rates than in seeing that the financial position of the undertaking is unassailable. Consequently, when Committees propose to take profits for the relief of the rates, the treasurer is not so concerned about the matter as the manager of the Department would be.

Contributing to the Rates.

Many glaring examples of the effect of the policy of contributing profits to the rates can be seen by studying the accounts of undertakings. In one case that was brought to the writer's notice a few months ago, the Council in one year voted the whole of the profits for the following year, estimated at £9,000, to the rates, notwithstanding the fact that they had a whole engine room full of obsolete plant.

In the result the surplus only amounted to £7,000 ; not to be beaten, the Council in the next year voted £6,000 to the rates, to find that the surplus was £4,000 only. In this case, if the financial matters had been in the hands of the manager of the undertaking, strenuous efforts would have been made to prevent such a suicidal policy from being adopted.

Possibly the undertaking in question had received rate aid in previous years, but if it had, the policy should have been to put the undertaking in a sound, financial position before paying the money back.

The duty of Councils and Committees is not to bleed undertakings of their surplus profits, but to see them placed on a firm financial footing, and then to devote the larger portion, if not all the profits (after paying back to the rates any sums taken for the undertaking) to the strengthening of reserves, and to the reduction of the price of electricity to as low a figure as possible.

Mr. Pearce's suggestion that a limit should be placed by Parliament on the contributions to be made to the rates is a good one, as such a law would strengthen the hands of those members of the Committee or Council who are anxious to protect the assets of the undertaking under their charge.

Profits should be Devoted to Improving Undertaking.

The policy of devoting all profits to the undertaking while being the soundest from the point of view of the financial

stability of the undertaking, would, in practically all cases be the best for the district. A cheap supply of electricity is one of the necessities of modern life, and is bringing prosperity to many towns by encouraging the use of machinery and causing industries to be established that would otherwise not exist, or which would be founded elsewhere.

The argument that the credit of the town is pledged for the benefit of a few consumers is one that cannot be maintained nowadays, as, apart from the fact that nearly everyone uses electricity either in his home, office, or in the works where he may be employed, all ratepayers would stand to benefit from any increased prosperity arising from the causes indicated above.

The Raising of Capital.

There are two principal ways that are adopted by Corporations for the raising of capital:

(1) By the issue of stock.
(2) By the borrowing of money on mortgage of the district rate.

The money has to be repaid in either case within a term of years fixed by the Local Government Board after taking into consideration the character of the assets.

Issue of Stock and Sinking Funds.

The first method is somewhat cumbersome, especially in view of the varying terms of years which the Local Government Board now grant. It also involves the establishment of a Sinking Fund, which is usually invested in some Trustee security, and as this investment rarely brings in the same rate of interest as is paid on the stock, increased contributions have to be made to the Sinking Fund; while if the securities purchased for the Sinking Fund depreciate (as they may do from causes entirely outside the control of the Corporation) before the date at which they have to be realised, this also has to be made up by additional contributions to the Fund.

When issuing stock terms might be arranged to pay off a certain amount each year, a ballot being held to decide the scrip to be surrendered. This is a cumbersome method, however, and the better scheme seems to be to invest the Sinking Fund in the undertaking, using the money to purchase new machinery instead of raising further capital. This is an eminently sound and practical method of dealing with the question, and ensures that the rate of interest is the same as that on the original loan.

It is open to any Corporation to invest their Sinking Funds in their own undertaking in the manner suggested, this course being provided for by the Local Government Board Stock Regulations of 1901 and 1902, amending those of 1891 and 1897. All these regulations are issued under the provisions of the Public Health Act of 1890.

Mortgages and their Repayment.

Probably the simplest method by which a Corporation can raise money for electricity supply purposes is by the borrowing of money from companies, societies, or individuals, a mortgage on the district rate being given as security.

A separate mortgage is usually prepared for each loan required, the period for repayment being that allowed by the Local Government Board. Each loan is treated separately so that no complication arises from these varying periods.

Repayment can be, but very seldom is, made by equal instalments of principal each year during the period, interest being calculated on the amount outstanding. Under this system the first years bear a much larger burden than the later years, as although the amount of principal is equal in each period, the amount of interest diminishes owing to the capital sum being gradually reduced.

The more usual method is to repay the loan by way of annuity, an equated payment of principal and interest,

calculated so that while the interest is large the repayment is small, making the burden on each year's working equal.

Many Corporations accept sums from small depositors, for long or short periods, paying various rates of interest according to the term. By this means they obtain money on slightly better terms than would be the case if they borrowed larger sums from other sources.

Revenue Contributions to Capital Outlay.

The Grimsby Corporation have never taken up a loan for their electricity undertaking for any period of less than fifteen years. The Local Government Board has approved the borrowing of money for certain purposes with the term of repayment fixed at five and ten years, but in these cases the money has been taken out of the profits of the undertaking. This has saved expenses in negotiating the loan and interest. In this way the undertaking provides for all new meters, public lamps, and posts, while it also provides in the same way for small extensions of mains and for the wages paid to men in permanent employ when working on capital account.

Temporary Loans.

There was an interesting note in the Press some time back stating that the St. Marylebone undertaking were borrowing £10,000 from the St. Marylebone Borough General Fund account at 2½ per cent. interest, this being the rate which the General Fund would have received from the bank.

Depreciation and Reserve Funds.

The assets of the undertaking are continually depreciating in value, and it is the duty of the Committee and the manager to see that adequate provision is made for this, either by reduction of the capital or in some other way.

The amount of this depreciation in Corporation undertakings was for many years a bone of contention between the "municipal traders" and the "anti-municipalists," but it is now generally accepted that the position of the municipal undertaking is no different from that of any other trading concern, and that depreciation must be provided so that :

> The value of the assets at any time at least equals the capital outstanding, *i.e.*, the total capital raised, less the amounts repaid, or provided for repayment, and less the depreciation, reserve, and sinking funds.

To calculate the value of the assets at any time it is necessary to take the original cost and to write it down on the basis of the estimated number of years of life ; in addition an allowance must be made for possible obsolescence by the introduction of new and more efficient apparatus before the expiration of that period.

Great Differences of Opinion exist as to the Life of the Plant.

If the only consideration was the date at which the machinery would be worn out, the question would be difficult enough, but it is further complicated by the question of obsolescence mentioned in the last paragraph.

The following table shows the life of various classes of machinery estimated by the late Sir W. H. Preece in a report to the Bristol Corporation, and the figures given by Mr. Hammond in a paper read before the Institution of Electrical Engineers in 1907. Another column has been added with the figures for the periods in which loans have to be repaid, which the Local Government Board seem to work on at the present time.

TABLE No. 1.

LIFE OF PLANT.

	Preece Report to Bristol Corporation, July, 1906.		Hammond, April, 1907, I.E.E. Paper.	Repayment Periods sanctioned by Local Government Board in certain recent cases.
	Life if properly maintained. Years.	Residual Value at end of life. Per cent. of original cost.	Life if properly maintained. Years.	
Land	—	—	60	50
Foundations	100	nil.	60	30
Buildings	80	nil.	60	30
Boilers (Water Tube)	25	5%	—	15
Lancashire Boilers	22	3%	20	—
Dynamos and Alternators	30	8%	25	18
Conveyors	—	—	10	15
Engines and other Machinery	25	6%	25	18
Turbines	—	—	20	18
Cables (Armoured)	35	15%	25	—
Cables (Solid, in Wood Trough	40	12%	30	25
Cables (Ducts)	—	—	30	25
Services, either armoured or laid solid	—	—	—	15
Static Transformers	—	—	25	—
Rotary Converters.—Motor Generators	—	—	20	15
Accumulators	15	10%	15	10
Arc Lamp Posts	40	5%	—	10
Arc Lamps	12	5%	—	10
Incandescent Lamps and Posts	—	—	—	10
Motors	25	9%	20	—
Meters	12	2%	10	5
Switchgear Instruments	—	—	20	18
Tools and Sundries	10	5%	10	—
Oil and Air Filters	—	—	—	—
Water Recorders	—	—	—	15
Cranes	—	—	—	—
Cooling Towers	—	—	—	10

A Reserve Fund acts as a protection to the capital account, but it must be borne in mind that it may be called upon at any time to provide for a deficit in the revenue account ; any amount so transferred ceases to be available for depreciation, as it has passed out of the capital account.

In providing depreciation, therefore, a margin should be allowed, over and above the calculated amount required, to provide for such a contingency.

If the loan, out of which any machinery is purchased, is repaid within a period which exactly equals or is shorter than the actual life of the plant, nothing further is required in the way of depreciation ; with the short periods now being granted by the Local Government Board there is every probability that this is what is occurring with recent expenditure, and it is highly probable that the machinery will, in most cases, be in efficient use after the whole of the loan has been repaid. Most undertakings, however, have obsolescent machinery in use on which loans are still outstanding. For instance, it was noted recently that an undertaking in London wished to replace machinery purchased out of money repayable in forty-two years ; the period was more than twice the time that the plant had been suitable for the purpose for which it was provided. In another case where a large number of engines of one size were put down, these were out of date before business had developed sufficiently to provide load for all the sets.

In the Grimsby accounts there is no depreciation fund so-called, but this is represented by the repayment of loans, the revenue contributions to capital outlay, the Reserve Fund and the Sinking Fund.

Where loans are redeemed on the equated payment system, the amounts shown as actually repaid, are not a

true criterion of the provision that has been made for depreciation. To ascertain this it is necessary to consider the proportion of the total liability that has been met; thus, after ten years payments on a loan running for twenty-five years the undertaking has met ten twenty-fifths of its liability, and for the calculation of depreciation, therefore, it is only fair to assume that ten twenty-fifths of the loan has been paid off. In the case of the Grimsby undertaking the loans actually repaid and accrued as shown in the accounts at March, 1913, were £24,570, but the proportion of the loans provided for calculated on the above basis works out at £33,681 ; this is the figure that should be taken into account when considering if the correct amount of depreciation has been provided. The Sinking Fund in this case is invested in securities, but the position is not altered if it is used for the purchase of capital assets as suggested above.

The policy should be as far as possible to avoid locking money up in outside securities, but to put all the money back into the business, only keeping as liquid assets such sums as may be thought necessary to meet a possible deficit in revenue account, or for dealing with any case of scrapping of plant, as when this occurs the Local Government Board require the amount of loan outstanding on the particular item of plant scrapped to be paid out of revenue.

It is probable, however, that the Local Government Board would give permission to the borrowing of the whole amount required for new plant to replace obsolete, if sufficient depreciation had been provided and ear-marked in the accounts to meet the whole amount outstanding on the plant to be scrapped, even if such depreciation had already been invested in the undertaking in the form of new assets. The accounts would have to show the transactions quite clearly somewhat in this form :

DEPRECIATION FUND.

	£		£
To amount withdrawn and applied to Capital Outlay ..	830	*By* Depreciation on Engines and Dynamos purchased from loan of 1901. Brought forward from last year ..	590
		By Contributions for the current year as per Nett Revenue Appropriation Account ..	240
	£830	Total to date ..	£830

SCRAPPING AND RENEWING OF PLANT.

The amounts spent out of revenue in writing off from capital account plant that has been scrapped, and in renewing short-lived assets on which there is capital outstanding, are contributions to depreciation; records should therefore be kept of such sums so that they can be taken into account in considering the financial position of the undertaking.

Sums spent in alterations which do not increase or renew the life of any portion of the machinery cannot, strictly speaking, be considered as depreciation, although the alterations may have been necessary to accommodate up-to-date plant.

The policy of scrapping inefficient and out-of-date machinery is one that has not always been adopted in the past as freely as it should have been. One still sees good engine rooms filled up with obsolete plant. This occupies land and buildings, while additional land and new buildings are being provided to accommodate further machinery. The reason usually given for this course is that the undertaking cannot afford to scrap the plant.

This is probably true, and has frequently been due to the profits in the past having been taken to relieve the rates; but if the policy of investing all surplus profits in the business is consistently pursued, these and many other difficulties will disappear, as the saving in interest and repayment will very soon begin to make itself felt and the profits of the undertaking will be proportionately increased.

Calculation of Depreciation for Grimsby Undertaking.

The depreciation that should have been provided for the Grimsby undertaking, calculated on the figures for life shown in the table above as being the periods now granted by the Local Government Board is £54,714.

The depreciation actually provided, taking into account the items that have been referred to is:

	£
Proportion of Loans provided for	33,681
Reserve and Revenue Contributions to Capital ..	8,581
Sinking Fund	6,197
Reserve Fund	4,706
Renewals of short-lived plant and plant scrapped written off	3,140
	£56,305

The depreciation provided is therefore greater than the calculations show to be necessary, leaving a margin for contingencies as previously recommended.

Working Capital.

It is well known that no provision was made in the Electric Lighting Acts for undertakings raising the necessary working capital, and this is one of the matters that is dealt with

in the I.M.E.A. Bill. In Grimsby the difficulty is got over by not investing the Reserve Fund, but leaving it in the ordinary banking account. The Local Government Board recently reminded the Corporation that, under the Electric Lighting Acts, this money should be invested, but it was pointed out in reply that if this were done the only alternative would be to borrow money from the bank, and that the Corporation had no powers to do this; also, that the course which they had adopted was more economical, as the Reserve Fund, if invested, would only have earned about $3\frac{1}{2}$ per cent., whereas the bank would have charged 5 per cent. for the overdraft. The necessity for working capital was also pointed out to them, and the Board have not raised any further objections.

Financial Statistics and Records.

In order that a proper check may be kept on the development of the undertaking and to keep a continuous record of the effect of any changes in policy, the author has found it convenient and helpful to keep certain statistics in addition to the usual detailed table of costs.

These are given in the tables at the end of the paper, and in addition similar figures are given for Southampton, Norwich, and Ipswich.

The following figures taken from these tables may be of interest:

	Grimsby.		Ipswich.		Norwich.		Southampton.	
Year ending ..	1907.	1913.	1908.	1913.	1907.	1913.	1908.	1913.
No. of Consumers per mile of distributor ..	31·5	44·2	31	62·2	101	92	50*	59*
Total Revenue per mile	£ 568	£ 526	£ 744	£ 920	£ 808	£ 793	£ 1,513*	£ 1,062*
Revenue per Consumer.	£ 15·1	£ 9·6	£ 24·2	£ 15·2	£ 8·15	£ 8·87	£ 30·4	£ 18·1
Revenue per £ Capital spent on Mains and Services (exclusive Public Lighting) ..	£ s. d. 0 6 11	£ s. d. 0 8 3	£ s. d. 0 12 0	£ s. d. 0 12 7	£ s. d. 0 7 10	£ s. d. 0 8 5	£ s. d. 0 9 2	£ s. d. 0 9 8
Average Cost per Service	3 19 10	2 17 0	4 2 1	3 8 5	4 0 0	3 5 0	3 4 3	3 19 8

* Per route mile in the case of Southampton.

PART III.—COST OF SUPPLY.

In any commercial undertaking it is very necessary to ascertain accurately the cost of manufacturing the article that is being sold, and as a rule there is no difficulty in doing this.

With electricity supply, however, certain difficulties arise, and great care must be exercised and a careful analysis made if a correct idea is to be obtained of the cost of supplying each class of consumer. Many progressive managers advocate the principle of selling electricity not on the basis of cost but on what it will fetch in the market; but the writer is of opinion that this should not be done if it involves selling below what it costs, unless:

(1) It can be shown that selling at the proposed price will so reduce costs that ultimately a profit will be made; or

(2) That by selling at a loss other business, which would not otherwise be done, can be obtained upon which the losses can be made up.

It must not be thought that this proposition is a preliminary to an attempt to show that the energetic band known as the "Point Fives" are selling at too low a price; on the contrary it will be seen that electricity can be sold at their rates of charge with great advantage to most undertakings.

If electricity is being sold at a loss it will probably be to the short-hour consumers who are paying on a flat rate. Banks, offices closing at five, and early closing shops are a very poor proposition for the electricity supply undertaking unless a very high price is obtained. At a flat rate of $3\frac{3}{4}$d., the price in Grimsby, they almost certainly cause a loss to the undertaking at the present time.

Items in Cost Sheet.

In considering costs, allowance must be made for the following:

RUNNING EXPENSES.

(1) Generation.
(2) Distribution.
(3) Management.

CAPITAL CHARGES.

(4) Interest.
(5) Repayment.
(6) Depreciation.

It is a very simple matter to divide the expenditure under each of the above heads by the total units sold and, in this way, to obtain a figure for the cost per unit; but it has long been recognised that this is quite misleading, and that, though this gives the average cost of supply, it is no guide to the cost of supplying different classes of consumer.

Generation.

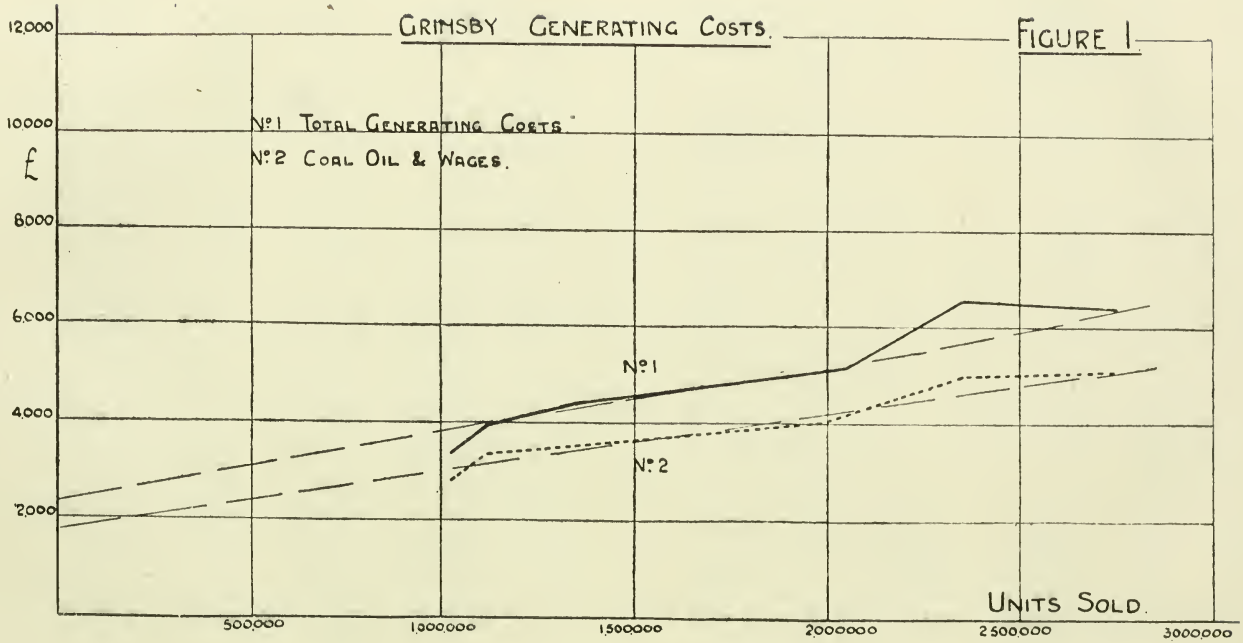
If the accounts for any undertaking be examined for a period of years, it will be found that, instead of the average cost varying in a somewhat haphazard manner, as might appear at first sight, it really follows a definite law as long as the conditions remain the same.

This law, which is similar in form to the Willans law for the steam consumption of an engine, is that the total cost of generation per annum (not the cost per unit) is equal to:

(1) A fixed sum plus;

(2) A small running cost per unit sold.

This is clearly shown by the diagram Fig. 1, which shows for Grimsby the amounts spent on generation during the years 1905 to 1911. These years have been chosen as the


GRIMSBY GENERATING COSTS.
FIGURE 1
12000
10000
£
8000
6000
4000
2000
No 1 TOTAL GENERATING COSTS
No 2 COAL OIL & WAGES.
No 1
No 2
500000
1000000
1500000
2000000
2500000
3000000
UNITS SOLD.

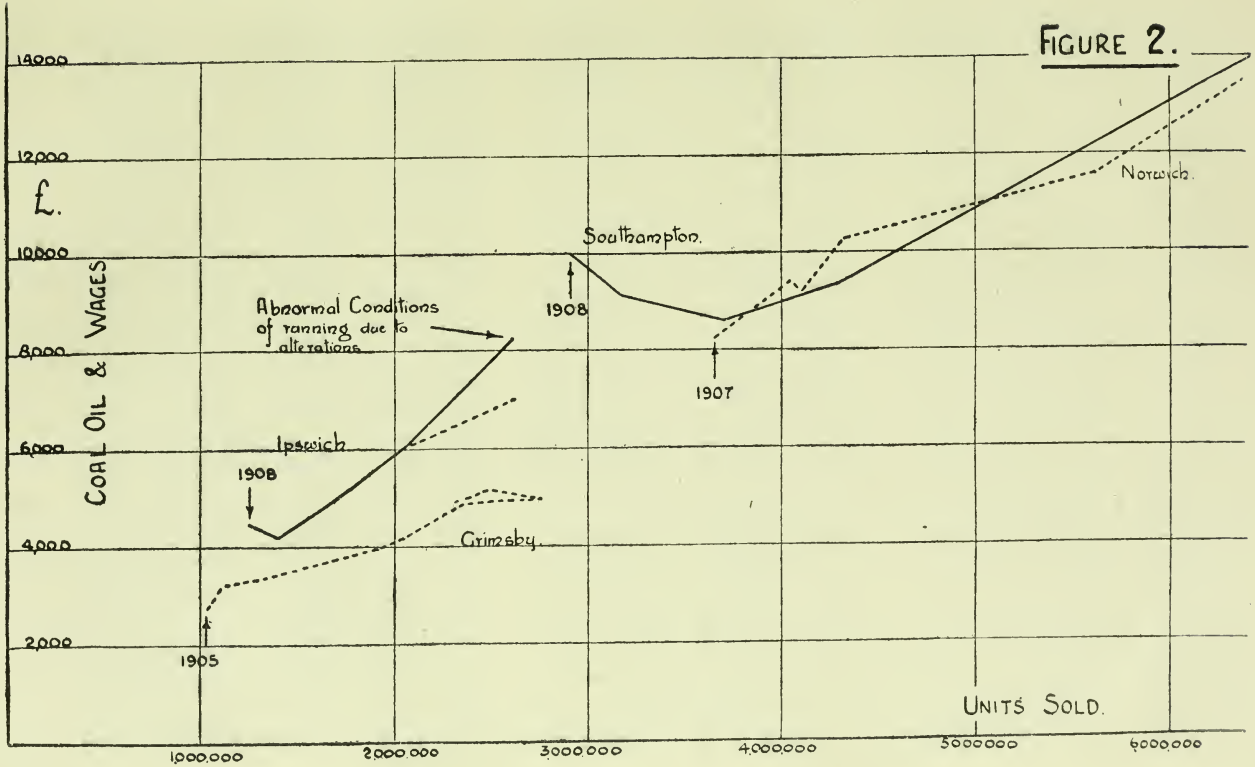


FIGURE 2.
£.
COAL OIL & WAGES
14000
12000
10000
8000
6000
4000
2000
Abnormal Conditions of running due to alterations
1908
Southampton.
1907
Norwich.
Ipswich
1908
Grimsby.
1905
UNITS SOLD.
1000.000
2000.000
3000.000
4000.000
5000.000
6000.000

conditions were fairly uniform, and the output was expanding very rapidly owing to the bulk supply that was then being given to the docks.

A straight line, No. 2, is drawn fairly easily through the points plotted for coal, oil and wages, the coal cost having been adjusted to a uniform price of 7s. 5d. per ton for ½-inch slack, this being the highest price during the period. The meaning of, or the equation for, this straight line is that the standing charges are £1,750, while the running cost, *i.e.*, the extra cost for oil, wages and coal, is ·313d. per unit.

Including repairs the points do not lie quite so well on a straight line; this is to be expected as the amount spent on this item will vary a good deal in each year, depending on whether any particularly heavy repair has to be undertaken. No. 1 straight line, however, lies fairly among the points; the formula for this is £2,450 plus ·341d. per unit.

The extra cost, therefore, of generating the electricity given for the bulk supply was ·341d. per unit, and the cost of generating the supply required by any consumer will be ·341d. plus a proportion of the standing charges of £2,450.

Fig. 2 shows coal, oil and wages plotted for four towns. It is interesting to note how the curves for Ipswich, Norwich and Southampton agree together, that for Grimsby falling below, probably due to the lower cost of coal in this district.

It is difficult to decide how the standing charges should be allotted; they have to be met, and in considering the cost of each class of supply, a proportion must be debited to each. The only satisfactory method seems to be to take them in proportion to the maximum demand. If the charges remain constant, as they will until the conditions are changed, *e.g.*, by the increased size of the station involving greater standby losses, the standing charges per kilowatt will be reduced as the M.D. increases.

In certain cases where new classes of business are being considered it may be advisable to ignore the standing charges, as these are being met by the revenue received from existing supplies. This is the attitude adopted by the " Point Fives," and it is a reasonable one provided that their charge covers the extra or running cost of supplying the extra units, any extra capital charges involved, and leaves a margin of profit for the benefit of the undertaking.

The division of the generating expenses into (1) Standing Charges, and (2) Running Costs, was advocated by the " Joint Committee of the I.M.E.A. and M.T.A. on charges for electrical energy for traction purposes from combined stations," and they gave a method of calculation.

Applying their method to the Grimsby accounts for the year 1912–13, two years later than the last point marked on the curve in Fig. 1, gives the division as :

Standing Costs £2,394, and Running Costs ·36d., figures sufficiently near to those proved to be correct by the straight line No. 1 in diagram Fig. 1. The details of the calculation are given later.

Distribution.

All distribution costs are standing charges ; the amount does not depend on the units sold, but on the extent of mains laid and the breaks-down in the year.

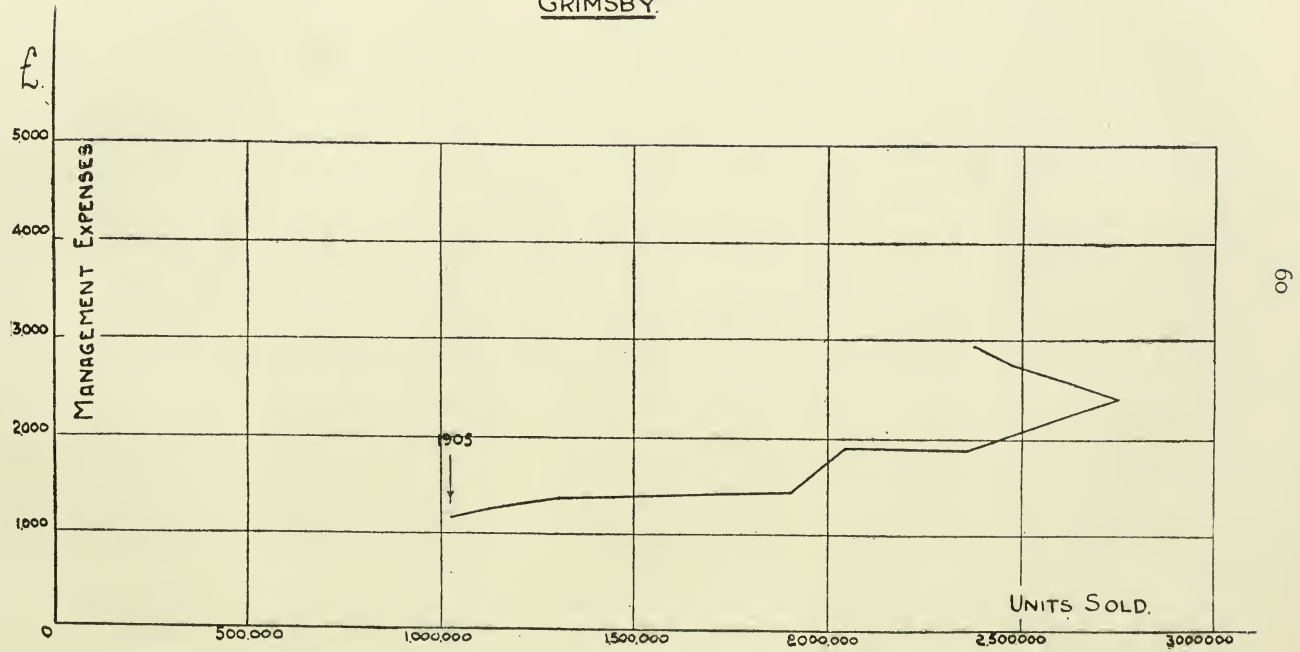
Fig. 5 shows the distribution costs for various towns plotted against the length of mains laid. Abnormal expenditure on repairs is shown in the case of Norwich and Southampton.

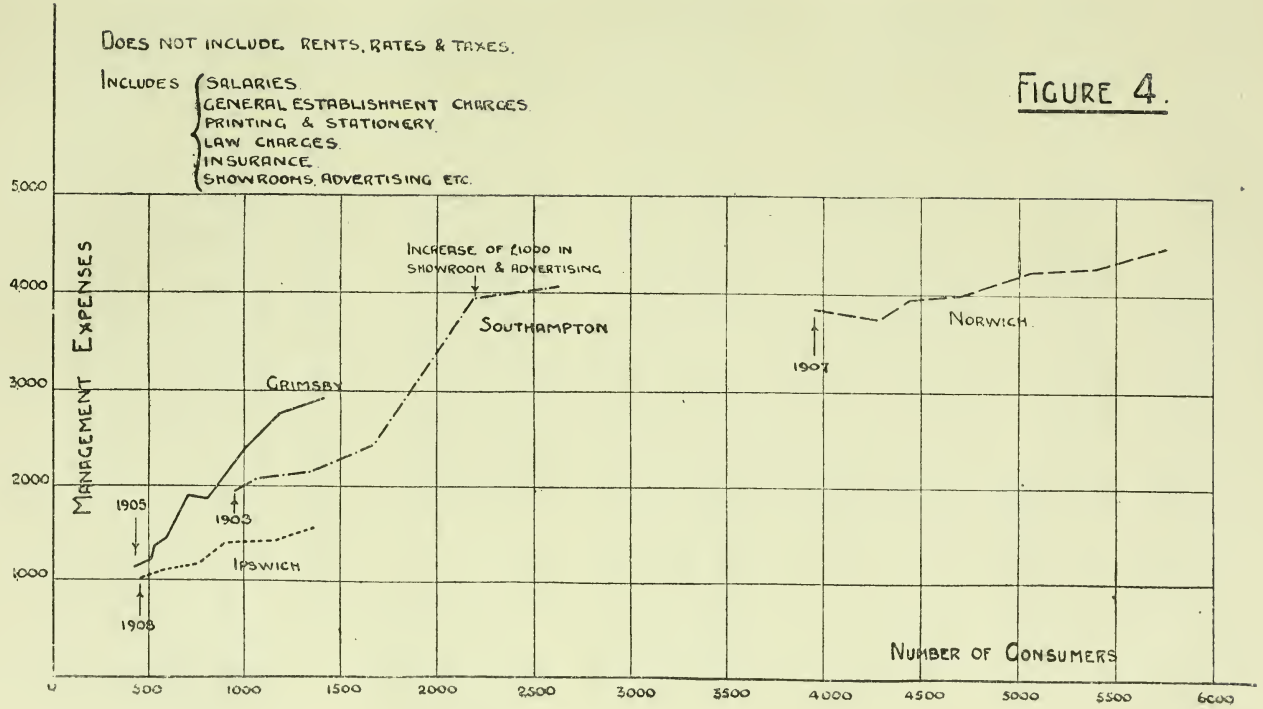
Management.

The inspection of a number of accounts for about the same size of town reveals large variations in the totals for management, even when the outputs are not dissimilar.

FIGURE 3.

GRIMSBY.




DOES NOT INCLUDE RENTS, RATES & TAXES.
INCLUDES SALARIES.
GENERAL ESTABLISHMENT CHARGES.
PRINTING & STATIONERY.
LAW CHARGES.
INSURANCE.
SHOWROOMS, ADVERTISING ETC.
FIGURE 4.
MANAGEMENT EXPENSES
5000
4000
3000
2000
1000
0
INCREASE OF £1000 IN SHOWROOM & ADVERTISING
SOUTHAMPTON
GRIMSBY
1905
1903
IPSWICH
1908
1907
NORWICH
NUMBER OF CONSUMERS
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000

The differences are due to the different conditions obtaining, the varying degree of progressiveness of the management, and the facilities offered to the public.

Where a Tramway Department and a Sales Department are in operation, the management charges may be less owing to a proportion of salaries and other expenses being debited to each Department.

If the management is pushing with an advertising scheme in operation, and there is in consequence a large amount of new business coming in each year, requiring a considerable number of new services and large extensions of mains and plant, the management costs are sure to be higher than where the policy is to sit waiting for customers.

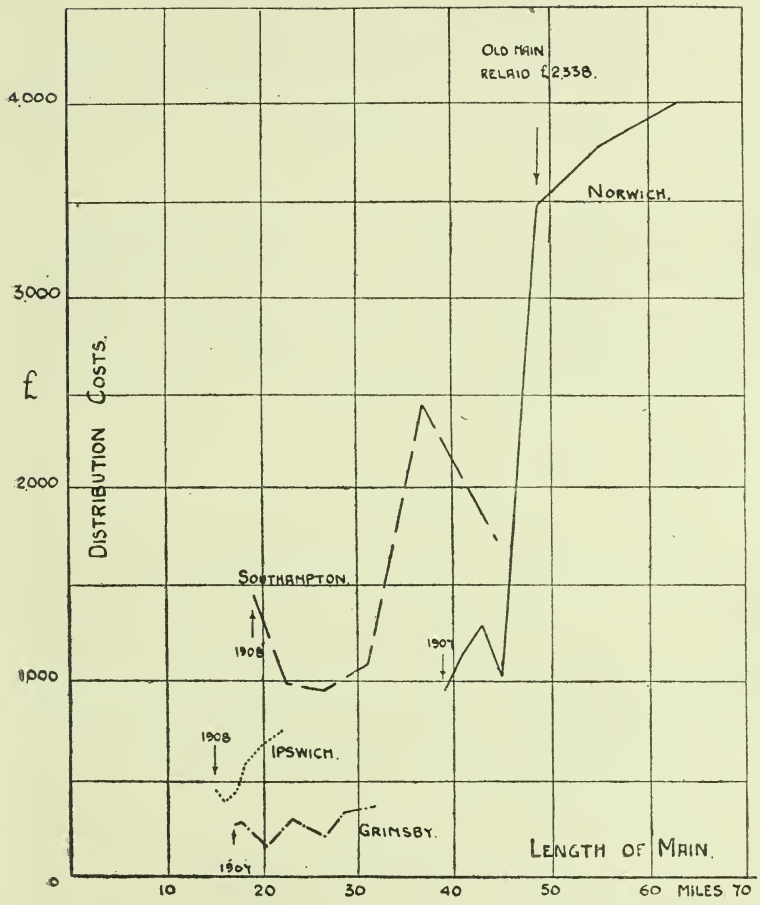
Management expenses do not depend on the units sold ; this is proved by Fig. 3, which shows the management costs increasing with a reduction in output. This reduction was due to the bulk supply to the Railway Company ceasing, but management costs increased as the supply to private consumers was rapidly developed.

Fig. 4 shows that the cost of management depends to some extent on the number of consumers ; where conditions are uniform, the costs follow a Willans law, with a large initial expense depending on the facilities offered as explained above, and a small increase with the rise in the number of consumers.

Apportionment of Management Costs.

The greater part of the management expenses are therefore fixed charges. These expenses can be divided into two principal items, one the expense due to the running of the undertaking and the other due to what may be termed development work in seeking and providing for new business. In the case of the Grimsby undertaking, fully one-third of the management should be debited to this development ; at

FIGURE 5.


OLD MAIN RELAID £2338.
NORWICH.
4,000
3,000
£
2,000
1,000
0
DISTRIBUTION COSTS.
SOUTHAMPTON.
1908
1907
1908
IPSWICH.
GRIMSBY.
1907
LENGTH OF MAIN.
10
20
30
40
50
60 MILES 70

first this may seem a large proportion, but it must be remembered that this account bears the engineering charges for all new extensions, with the exception of any special draughtsman's work.

In large commercial undertakings a similar problem has to be dealt with, and in these cases it is no uncommon thing for a special development fund to be created for extensive advertising, or similar expenditure, which, while for the ultimate good of the undertaking, is not immediately remunerative.

In allocating the management costs the expense due to the running should be debited to the various classes of supply in proportion to the maximum demands, while it is suggested that the development expenses should be allocated in proportion to the profit made. That is, that it should be taken out of profits, and not shown as an expense against any particular class of supply.

Rates and Taxes.

The principle of the assessment of electricity undertakings for rating purposes is to estimate the profit that would be made by a hypothetical tenant, so that actually rates as well as income tax are based on profits. These charges, therefore, should also be allocated in proportion to the profit made on each class of supply. They need not be taken into account when considering the prices to be fixed for new business, as unless a profit is made the assessment for rates or income tax will not be increased.

Example.

The following figures showing the division of the working costs in the way described may be of interest. They are worked out on the accounts of the Grimsby undertaking for the year 1912–13.

The costs are divided as follows :—

(1) Running costs proportional to units sold.
(2) Standing charges proportional to M.D.
} These two make up generation and distribution.

(3) Rates, taxes, and portion of Management proportioned to various supplies according to profit made.
(4) Balance of Management proportional to M.D.

Working on the basis suggested by the I.M.E.A. Committee the figures are as follows :—

DIVISION OF COSTS SHOWN IN THE GRIMSBY ACCOUNTS FOR THE YEAR 1912–13.

(1) Running Costs.

	£	Per unit sold.
Coal 75 per cent. wt., 6,274 tons	2,345	·235d.
Oil and Stores, 75 per cent.	208	
Wages, 50 per cent.	787	
REPAIRS to :—		
Buildings	—	
Engine House Plant, 50 per cent.	74	
Boiler House Plant, 25 per cent.	88	
Other Machinery, 25 per cent.	57	
Accumulators	—	
Distribution	—	
Total	£3,559	= ·36d per unit sold.

(2) Standing Costs Proportional to M.D.

	£	
Coal, 25 per cent. wt., 2,091 tons	780	
Oil and Stores, 25 per cent.	69	
Wages, 50 per cent.	788	
REPAIRS to :—		
Buildings, 100 per cent.	183	
Engine House Plant, 50 per cent.	74	
Boiler House Plant, 75 per cent.	264	
Other Machinery, 75 per cent.	172	
Accumulators, 100 per cent.	64	
Distribution, 100 per cent.	391	
Total	£2,785	= £1·96 per kw. of M.D.

(3) Charges Proportional to Profit.

	£
Rates and Taxes	1,175
Proportion of Management due to development	819
Total	£1,994

(4) Balance of Management Proportional to M.D.

	£
Management expenses	2,495
Law and Insurance	163
	£2,658
Less Management chargeable to development ..	819
Management proportional to M.D.	£1,839 = £1·3 per kw. of M.D.

Capital Charges.

It is recognised that the capital charges must be allotted according to the M.D. on the plant, but a difficulty arises in ascertaining how the M.D. of any individual consumer or class of consumer affects the total.

To continue the example given above, the capital expenditure at Grimsby for the same year, 1912–13, can be divided as follows :—

Division of Capital Expenditure.
Total maximum demand 1,520 kws.
Capital cost of :
Buildings and Plant, £36 per kw. of total M.D.
Mains, £26 per kw. of demand from consumers using mains.
Services, £7·55 per kw. of demand from consumers using mains.
Non-productive Capital (Office Buildings, Furniture, Law Charges, etc.), £4·7 per kw. of total M.D.

The average rate for interest and repayment not including depreciation is 6·3 per cent.

Costs of Each Class of Supply.

It is an interesting exercise to work out the cost of each class of supply, taking the above as a basis in the manner shown below for arc lighting. This has been done for Grimsby, every pound spent on revenue account or for capital charges being allocated and an extra allowance for depreciation being also made.

The information so obtained is of extreme value to the management, though as it is not of general interest the one example will suffice to show the method adopted.

Cost of Public Lighting.

Arcs. 1912–13.

Revenue, £1,609. Units, 108,438. M.D. 40 kws.

(Excluding all special expenditure for Public Light. Including cost of Electricity only.)

			Total.	Cost per unit in pence.
1. *Revenue Expenditure.*				
Arc Lamp Repairs ..	£194			
Wages	142			
		£336	—	—
2. *Capital Charges.*				
Special Arc Mains, 6·3% on	£ 1,403			
Arc Lamps and Posts ..	2,926			
Buildings and Plant, 40 kws. × £36	1,430			
Distributing Network, 40 × 26	1,040	—	£167	·37d.
Non-productive Capital, 40 × 4·7	188			
Interest and Repayment. Average rate 6·26% on	£6,987	= £438	—	....
3. *Depreciation.*				
Extra beyond that provided by repayment of loan :—				
On special Arc Mains ..	£1,403			
On Arc Lamps and Posts	2,926			
At 6% making 12·26% ..	£4,329	= £260	—	—
On Buildings and Plant. ·75% on	£1,540	= £12	£12	·03d.
4. *Electrical Energy.*				
(1) Running Costs : 108,438 units at ·36d.	£163			·36d.
(2) Standing Costs : 40 kws. at £1·96 ..	79			
		£242	£242	·175d.
For (3) and (4) Standing Costs Proportional to Profit and Management Proportional to number of Consumers, *see* below.				
5. *Electrical Energy.*				
(3) Standing Charges Management : 40 kws. at £1·3 ..		£52	£52	·115d.
(4) Rates, Taxes and Development, proportioned according to profit		£169	£169	·364d.
Total		£1,509		
Nett Profit ..		100		
Total Revenue		£1,609	£642	1·414d.
Total, except last item (4) ..		£1,340		
Gross Profit		£269		
		£1,609		

Cost of Bulk Supply or for Cooking.

It is also possible to estimate what the cost of bulk supply or cooking supplies would be under the present conditions at Grimsby; in fixing the price to be charged it should be borne in mind that both capital and running costs will be reduced with further extensions of plant and the introduction of larger and more economical machinery.

Taking the above figures the costs work out as follows :—

Extra Capital Cost due to increased M.D. on peak.

	£
New expenditure on Buildings and Plant, say	25
New expenditure on Mains, say	10
Total	£35

Cost of service would not be increased.

Capital Charges on the periods now granted by the Local Government Board would be about 7·25 per cent = £2 11s. per annum per kw. of M.D. on peak due to bulk supply, or if the average figures on the existing plant be taken the Capital Charges would be 6·3 per cent. on £62 = £3 18s. per kw.

Extra Running Costs :

(1) Extra cost per unit, decreasing with introduction of new plant	·36d.
The following would not be increased :	
(2) Standing charges	—
(3) Rates and Taxes	—
(4) Management	—
Total	·36d.

If the consumer taking a supply for cooking is also taking a supply for lighting he would pay a proportion of 2, 3 and 4 in the charge for the latter.

The net extra cost under present conditions, with coal at the highest price it has reached in the last five years, would therefore be £2 11s. per kw. of increase in the peak

on the basis of new plant, or £3 18s. if the average cost of the present plant be included, with an extra of ·34d. to ·36d. per unit sold.

Comparison of Flat Rate and Rateable Value System.

At present electricity is sold for lighting in Grimsby at 3¾d. per unit; comparing this with a rateable value system of 15 per cent. and ½d. per unit, the latter, taking an average over a number of houses assessed at about £20 per annum, seems to bring in about £1 per annum more in the cases where electricity is used for lighting only. That is to say if these houses adopt the new scale and go in for heating or cooking they will pay about £1 per annum and ½d. per unit for the electrical energy used for this purpose.

Maximum Demand due to Cooking Load.

The experience of other towns appears to be that the increase in the peak due to cooking is very small indeed. Mr. Long, in his paper in 1912, estimated it at 12½ per cent. of the connected demand. In a house such as described above, a "tricity" or other cooker with a total capacity of 2·5 kws. would be equal to the requirements, so that on these figures the demand per consumer would not be greater than ·3 kw. The capital charges due to this would be £1 4s. if the average of present figures be taken, or 15s. if the figures for additional plant be considered. Against this the consumer would pay £1.

The following table shows the load factor in the last few years for Southampton, two sets of figures being given, one including the whole of the electricity sold, and the other with the units sold for heating and cooking omitted. It will be seen that in the second case the load factor is fairly steady, while there is a considerable increase taking cooking

into account. This seems to bear out the contention that the effect of the cooking load on the peak is very small.

Load Factor, Southampton.

Year ending March	1. Including all Units sold.	2. Excluding Units sold for Cooking.
1910	19·37	19·28
1911	19·6	18·73
1912	21·4	19·75
1913	22·23	19·35

Electricity at a Halfpenny Per Unit.

From these figures it is evident that electricity can be sold for cooking under the conditions at Grimsby on a rateable value system of 15 per cent. and ½d. at a substantial profit. Further, that the increase in the load and, in consequence, the more economical running of the whole plant are bound to re-act to the advantage of the undertaking and to cause an increase in the net profits.

Use of Large Plant.

Many of the moderate-sized towns started their undertakings with small reciprocating engines of 100 and 200 kws. A very large number have now installed, or are considering the installation of, turbines of upwards of 1,000 kws. capacity. The use of this size and type of plant will undoubtedly bring down the generation costs, and there is no reason why towns of 100,000 inhabitants should not be in a position in a few years' time to utilise turbines of twice this output.

With units of this size it will be necessary to use alternate current generators, or geared turbines, in order to get the best steam consumptions. and in several cases the former have been installed in continuous current stations, a rotary converter being also erected in the station to make the conversion.

GRIMSBY.

	1909.	1910.	1911.	1912.	1913.
Ordi	—	—	—	£8 10s. per kw.	+ 1d. per unit.
Li	>	<	3¾d.	>	>
P	>	<	2¼d. to ·95d.	>	>
H-	>	<	1d.	>	>
Bi	—	—	—	—	—
Aver	1·87	1·88	1·74	1·89	1·93
Capa	1,716	1,716	1,716	1,716	1,716
Max	1,248 kw.	1,469 kw.	1,567 kw.	1,451 kw.	1,520 kw.
Tota	18·69	18·3	20·0	19·48	17·9
Num	697	803	1,006	1,174	1,404
	34·5	34·7	37·6	41·0	44·2
	151	169	493	528	629
	7·47	7·33	18·55	18·41	19·7
Reve	£17,142	£19,487	£21,422	£21,233	£21,330
Reve					
Li					
He	344	320·5	306	308	323
Po	77	85·5	88	94·7	100
Pu	85	77	91	110	104
Tota					
	505·3	482·2	484·5	514·4	526·9
Aver	£12·3	£11·7	£10·4	£10	£9·6
Reve					
£ (	6s. 6d.	6s. 8d.	7s. 3d.	7s. 10d.	8s. 3d.
Ditto	5s. 4d.	5s. 7d.	5s. 9d.	6s. 1d.	6s. 7d.
Expe					
	£36·5	£37·7	£37·5	£38·5	£38·8
Expe					
s	£45·4	£41·6	£35·8	£32·2	£29
Aver	£3 8s. 0d.	£3 3s. 0d.	£2 19s. 9d.	£3 0s. 3d.	£2 17s. 0d.

Year ending March	IPSWICH. 1908.	1909.	1910.	1911.	1912.	1913.	GRIMSBY. 1907.	1908.	1909.	1910.	1911.	1912.	1913.
Ordinary Prices Charged	—	—	—	<—£7 per	kw. + 1d.	per unit.—>	—	—	—	—	—	£8 10s. per kw.	+ 1d.per unit.
Lighting	<—		—4d.	——	——	—>	<—	—4d.—	—>	<—	—3½d.—	——	—>
Power	<—		2d. to 1½d.	——	——	—>	<—	2¼d. to 1d.	—>	<—	—2¼d. to ·95d.—	——	—>
Heating	<—	2d. to 1½d.	—>	<—	— 1½d. —	—>	<—	— 1½d. —	—>	<—	— 1d. —	——	—>
Bulk	—	—	—	—	—	—	—	—	—	—	—	—	—
Average Price received	2·1	2·1	2·12	2·13	2·0	1·8	2·19	1·88	1·87	1·88	1·74	1·89	1·93
Capacity of Plant	1,511	1,511	1,511	1,511	1,511	3,511	1,400	1,400	1,716	1,716	1,716	1,716	1,716
Maximum Demand	706 kw.	837 kw.	944 kw.	1,147 kw.	1,313 kw.	1,320 kw.	907 kw.	1,225 kw.	1,248 kw.	1,469 kw.	1,567 kw.	1,451 kw.	1,520 kw.
Total Load Factor	20·48	19·15	15·43	19·1	17·9	22·6	16·45	17·7	18·69	18·3	20·0	19·48	17·9
Number of Consumers	466	603	731	884	1,130	1,350	527	595	697	803	1,006	1,174	1,404
,, Consumers per mile Distributor	31	38	42·3	49·5	57·3	62·2	31·5	34·0	34·5	34·7	37·6	41·0	44·2
,, Public Lamps	—	2	14	24	74	124	124	138	151	169	493	528	629
,, Lamps per mile of Distributor	—	—	0·81	1·34	3·75	5·7	7·38	7·88	7·47	7·33	18·55	18·41	19·7
Revenue. Total from all sources	£11,287	£12,701	£14,158	£15,619	£17,756	£20,474	£13,094	£16,208	£17,142	£19,487	£21,422	£21,233	£21,330
Revenue per mile of Distributor from :													
Lighting	329	364	395	433	448	447	398·8	375	344	320·5	306	308	323
Heating and Cooking / Power	105	121	122·5	140·5	211·5	277	72·2	96·2	77	85·5	88	94·7	100
Public Lighting	—	0·19	2·5	4·3	9·8	15·2	97	95	85	77	91	110	104
Total per mile (including Meter Rents) from Consumers using Mains	444	497	534	595	689	759	568·5	577·4	505·3	482·2	484·5	514·4	526·9
Average Revenue per Consumer	£14·4	£13·1	£12·5	£11·9	£11·8	£11·95	£15·1	£14·2	£12·3	£11·7	£10·4	£10	£9·6
Revenue from Consumers using Mains per £ Capital spent on Mains and Services	12s. 0d.	12s. 6d.	13s. 0d.	13s. 0d.	13s. 0d.	12s. 11d.	6s. 11d.	7s. 0d.	6s. 6d.	6s. 8d.	7s. 3d.	7s. 10d.	8s. 3d.
Ditto, excluding Public Lighting	12s. 0d.	12s. 6d.	13s. 0d.	13s. 0d.	13s. 0d.	12s. 7d.	5s. 9d.	5s. 10d.	5s. 4d.	5s. 7d.	5s. 9d.	6s. 1d.	6s. 7d.
CAPITAL.													
Expended per kw. of Plant, excluding cost of Mains, Services and Public Lighting	£43·6	£44·2	£44·7	£46·2	£54	£25·3*	£40·8	£44·4	£36·5	£37·7	£37·5	£38·5	£38·8
Expended on Mains and Services per Consumer	£40	£33	£29	£26·6	£23·4	£22·9	£52	£48·4	£45·4	£41·6	£35·8	£32·2	£29
Average Cost per Service	£4 2s. 1d.	£3 15s. 5d.	£2 15s. 0d.	£3 8s. 1d.	£2 19s. 0d.	£3 8s. 5d.	£3 19s. 10d.	£3 16s. 0d.	£3 8s. 0d.	£3 3s. 0d.	£2 19s. 9d.	£3 0s. 3d.	£2 17s. 0d.

* Boilers are not at present equal to the capacity of the plant.

	1909.	1910.	1911.	1912.	1913.
Or	—	—	—	—	—
	<———3½d. to 3d.———>		<3½d.to2½d.>	<———3d. to 2½d.——>	
	o 1d.———>	<————	————2d.	to ¾d.———	————>
	d.———>	<————	——— ½d. ——	————	————>
	—	—	—	—	—
Av	2·24	2·07	2·04	1·88	1·7
Ca	3,100	3,100	4,100	4,550	4,550
Ma	1,878 kw.	2,200 kw.	2,500 kw.	2,913 kw.	3,330 kw.
To	19·35	19·37	19·6	21·4	22·23
Nu	11,04	1,350	1,666	2,195	2,627
	49	51	53·3	59	59*
	172	668	1,049	1,276	1,541
	7·65	25·2	33·6	34·5	34·6*
Re	£30,441	£33,017	£37,381	£44,256	£47,676
Re					
I	621·8	617	597	566·8	501·8
I	98·2	108	85·3	94	100
I	87·8	132	154	161	153 *
To	844	895	861	842	782
Av	£15·4	£15	£13·3	£11·5	£10·6
Re	10s. 6d.	10s. 7d.	11s. 0d.	11s. 7d.	11s. 5d.
Dit	9s. 2d.	8s. 9d.	9s. 7d.	10s. 1d.	9s. 8d.
Ex	£48	£48·5	£39·3	£37	£40·3
Ex	£50·5	£46	£40·5	£33·2	£31·4
Ave	<———£3 4s. 3d.———>		<———£3 19s. 8d.———		————>

These are per route mile in the case of Southampton.

Year ending March	NORWICH. 1907.	1908.	1909.	1910.	1911.	1912.	1913.	SOUTHAMPTON. 1908.	1909.	1910.	1911.	1912.	1913.
Ordinary Prices Charged	—	—	—	—	—	—	—	—	—	—	—	—	—
Lighting	4½d.	or 12 per cent. on rateable value, plus			1d. per unit.	—	—	3½d. to 2d.	3½d. to 3d.		3½d. to 2½d.	3d. to 2½d.	
Power		3d. to ¾d.				1½d. to ¾d.		2d. to 1d.			2d. to ¾d.		
Heating	—	—	—	—	—	—	¾d.	1d.			½d.		
Bulk	—	—	—	—	—	—	—	—	—	—	—	—	—
Average Price Received	2·56	2·22	2·09	2·09	1·96	1·86	1·82	2·38	2·24	2·07	2·04	1·88	1·7
Capacity of Plant	2,474	3,504	3,504	3,504	4,104	4,104	5,290	2,100	3,100	3,100	4,100	4,550	4,550
Maximum Demand	2,244 kw.	2,434 kw.	2,850 kw.	2,894 kw.	3,124 kw.	3,697 kw.	3,977 kw.	1,538 kw.	1,878 kw.	2,200 kw.	2,500 kw.	2,913 kw.	3,330 kw.
Total Load Factor	14·48	17·24	16·3	16·25	17·62	17·33	18·62	21·52	19·35	19·37	19·6	21·4	22·23
Number of Consumers	3,962	4,253	4,425	4,692	5,041	5,395	5,762	962	11,04	1,350	1,666	2,195	2,627
,, Consumers per mile Distributor	101	104	103	103	104	98	92	50	49	51	53·3	59	59*
,, Public Lamps	—	—	—	—	—	1,036	1,961	138	172	668	1,049	1,276	1,541
,, Lamps per mile of Distributor	—	—	—	—	—	18·7	31	*7·2	7·65	25·2	33·6	34·5	34·6*
Revenue. Total from all sources	£32,277	£35,612	£37,189	£37,632	£41,729	£45,941	£51,162	£29,237	£30,441	£33,017	£37,381	£44,256	£47,676
Revenue per mile of Distributor from :													
Lighting	607	612	595·4	585·5	581·9	542·9	497·5	717·5	621·8	617	597	566·8	501·8
Heating and Cooking													
Power	162	214·3	227	199	218	206·6	206·7	113	98·2	108	85·3	94	100
Public Lighting	4·3	4·26	4·07	3·89	5·25	37·6	73·1	107	87·8	132	154	161	153
Total per mile (including Meter Rents) from Consumers using Mains	808	863	855	815	830	808	793	931	844	895	861	842	782
Average Revenue per Consumer	£8·0	£8·27	£8·27	£7·9	£8·0	£7·9	£7·9	£16·5	£15·4	£15	£13·3	£11·5	£10·6
Revenue from Consumers using Mains per £ Capital spent on Mains and Services	8s. 0d.	8s. 4d.	8s. 2d.	8s. 0d.	8s. 4d.	8s. 8d.	9s. 3d.	—	10s. 6d.	10s. 7d.	11s. 0d.	11s. 7d.	11s. 5d.
Ditto, excluding Public Lighting	7s. 10d.	8s. 3d.	8s. 1d.	7s. 11d.	8s. 4d.	8s. 4d.	8s. 5d.	—	9s. 2d.	8s. 9d.	9s. 7d.	10s. 1d.	9s. 8d.
CAPITAL.													
Expended per kw. Plant, excluding cost of Mains, Services and Public Lighting	—	£57·2	£58·2	£58	£50·7	£51	£43·3	—	£48	£48·5	£39·3	£37	£40·3
Expended on Mains and Services per Consumer	£20·2	£19·85	£20·3	£19·75	£19·2	£18·9	£18·8	—	£50·5	£46	£40·5	£33·2	£31·4
Average cost per Service	£4 0s. 0d.	£4 15s. 6d.	£3 15s. 8d.	£3 12s. 8d.	£3 2s. 0d.	£3 3s. 0d.	£3 5s. 0d.	—	£3 4s. 3d.		£3 19s. 8d.		

* These are per route mile in the case of Southampton.

If alternating current is to be generated it would be better to take advantage of high pressure to reduce the capital cost of the feeders. At the same time, it may be possible to arrange to supply a few large consumers with high-tension 3-phase current giving a slight advantage in the price.

Continuous current has served the moderate-sized town exceedingly well in the past, and for simplicity in generation and distribution it cannot be excelled, but the change to 3-phase is being forced by the changing conditions and it is as well to look ahead and recognise this.

General Conclusions.

A general review of the present commercial position of electricity supply shows that undertakings are passing through a period of great development, where an energetic and pushing policy has been adopted, and the outlook for the future is exceedingly bright. The use of electricity for power will undoubtedly continue to grow at a rapid rate; the demand in this connection is so well established that in these notes very little has been said about it. It must not be assumed, however, that this branch of business can be left to look after itself; on the contrary, it should be carefully tended and any inquiry closely followed up, otherwise business may be lost.

It has been seen that the sale of electricity for heating and cooking at ½d. per unit, or at least on a rateable value system of 15 per cent. and ½d., is a sound proposition, while the supply for charging vehicles should bring in a good revenue in the course of a year or two. There are financial rocks ahead of some undertakings, especially where the change from continuous current to 3-phase generation is made. This change, however, is already desirable in many towns, and will be to the advantage of the undertaking in the long run. The difficulties should therefore be faced as soon as possible, and if a conservative policy has been adopted and profits devoted to the strengthening of the financial position of the undertaking, this will be in a position to face any losses that may occur during the first year or two after the change.

DISCUSSION ON MR. VIGNOLE'S PAPER.

Mr. F. Ayton (Chief Electrical Engineer, Ipswich), in opening the discussion, said he imagined with regard to advertising that the dominant idea with which they would be inspired would be that with an almost insignificant outlay on publicity work, it was possible to give a very great stimulus indeed to the demand for electricity in any area. He had been advertising in Ipswich ever since the inception of its electrical undertaking more than ten years ago, but for several years he could trace very little advantage accruing from that advertising. One of the points to be remembered about publicity work was that immediate results were never obtained. To get satisfactory results the publicity work must be sustained, not fragmentary and spasmodic. It was necessary to keep on suggesting to the prospective consumer the advantages of electric supply for all purposes. He had used many means of bringing the advantages of electricity before the people in Ipswich, which was not a big town. It had a population of between 75,000 and 76,000 inhabitants, and at present he had only got mains laid in three-fifths of the area. One of the most valuable media which he possessed in publicity work was the advertisements upon the tramcar windows. He had found that the advertisement which brought in most was the one which consisted of only a few words suitably chosen, which a person sitting in the tramcar would think about, and one of these advertisements which told more than any other was one which read "Sunlight on tap is electric light. It makes the home more cheerful." People talked about that a great deal and there was no doubt about it that he got a great deal of business from it. It was a waste of money to put into the hands of a prospective consumer a great deal of matter to read in the form of pamphlets. He utilised also to a great extent in Ipswich, the mail card form of advertising which cost so little to send through the post, and which had just enough on it for a consumer to read and then throw away. If a consumer was sent a booklet, he probably did not read it at all or even look at it. The cost of publicity in Ipswich was very small indeed. In the year ended March 31st, 1914, he spent £141 in advertising and that was the greatest amount he had spent. The average from the years 1906–14 was just over £58, and for the £141 spent in 1913–14 he distributed nearly 23,000 different documents through the post. The result of that publicity work was that his average increase in connected load per annum during

the past six or seven years was 19·7 per cent. and the average increase in sales during the same period was 25·2 per cent. Whilst this was a very gratifying result, he was not satisfied that they had been doing anything like what could be done in the way of publicity work, but an engineer had little time to give to concocting publicity matter. He was not trained for it ; it took a long time to think out these things and therefore there was a need for a committee such as Mr. Vignoles had suggested, a central organisation which could plan publicity work for the whole of the country. He refused to believe that the majority of engineers were not alive to the necessity of advertising. He thought a great many of them wanted to do it, and that in a great many cases they were prevented from doing it by the apathy of their committees. On this point a Mr. Casson who was an American advertising expert, was over in England recently, and delivered a speech before an organisation of sales managers, and his words were not so much for engineers generally as a suggestion for converting chairmen if they did not believe in advertising. Mr. Casson said he once had a friend who did not believe in advertising, so he put in a small advertisement in a certain paper, "I will give a dollar for a cat," and signed his friend's name. Cats filled the streets for days afterwards and his friend who was summoned for obstruction now believes in advertising. This might be a way of converting chairmen who did not believe in advertising. It was very essential to remember the importance of service, and service did not mean just connecting up the consumer ; it meant keeping him satisfied and continually suggesting other uses for electricity. It also meant giving him a good supply, and at Ipswich they had found the advantage of good pressure regulation. Since he fitted automatic pressure regulators he had practically no complaints of voltage fluctuations, so that one of the first things to do was to ensure that the pressure regulation was good. He agreed also with Mr. Vignoles as to the necessity of encouraging the work of contractors. In Ipswich they had their own sales department and he found it a very useful weapon in promoting the progress of the undertaking. At the same time he recognised that there were contractors who did good work, and he did all he possibly could to encourage them and care should be taken that their juniors, in their enthusiasm for the work of the department, did not upset the contractors. He was quite with Mr. Vignoles as to the desirability of utilising profits for reducing capital expenditure. The curse of municipal electrical supply in some places was the way in which profits were filched from the undertakings to feed the rates. It seemed

to him the absolute negation of the municipal ideal to utilise one section of the inhabitants to benefit others who did nothing to obtain that benefit. The municipal ideal and the only justification for the municipal control of any public utility was to have one aim only, namely that of supplying at such a low price that the commodity was within the reach of every inhabitant in the borough, and this could only be done by keeping the charges low. At the same time one should utilise some of the money which was frequently given to the rates, for advertising the undertaking. The Association had representatives on the publicity committee from which great things were expected, but these representatives had practically been thrown out, and the reason they were thrown out was that the undertakings as a whole in the country did very little indeed to support the Publicity Committee. That was entirely wrong and the corporations owning electricity supply undertakings ought to be willing to assist handsomely in any organisation formed for publicity work. A central organisation founded and worked upon proper lines might do a great deal to relieve engineers of the worry of concocting publicity matter of their own. They ought not to have to do it and it seemed to him that the present time was a very appropriate one to form the committee which Mr. Vignoles had proposed and which the President also had in his mind when he read his address. Such a Committee would be extremely valuable because they were going to take advantage of the tremendous and fruitful field which was now opening up for the use of electrical supply in all directions, and he had it in mind after reading Mr. Vignoles paper, that it would be a splendid thing if from some vantage point of a future time, one could look back and discern in the 1914 Convention of the I.M.E.A. the starting point of a new era in electrical supply progress. It must be remembered that the prosperity of the electrical manufacturing industry hung to a large extent upon the prosperity and progress of the electric supply undertakings, and it would be a splendid and appropriate thing considering that Birmingham was so enterprising in her industries and had been the birthplace of so many municipal ideals, if some central organisation of the kind he had referred to could be created this year. It might be arranged in this way, that the Council be authorised to appoint a special Committee and invite the British Electrical and Allied Manufacturers Association, the Electrical Contractors Association, the Institution of Electrical Engineers; and the Cable Makers Association to appoint similar members to that Committee all of whom would meet to decide

what was going to be done for the future. An organisation of that sort would be an independent body and it would speak with one voice the needs of the electrical industry. He hoped Mr. Vignoles would see his way to put a resolution before the General Meeting, which he was sure would command universal support.

Mr. A. H. Seabrook, (Chief Electrical Engineer, Marylebone), said, there was one point upon which he would like to join issue with the author, although he agreed with him upon practically everything. It was as to selling powers in connection with electrical undertakings. He placed the very greatest importance upon municipal undertakings who had these powers, sticking to them and exercising them, and those who had not should get them if they possibly could, not from the point of view of profits on the apparatus sold, but on account of the numerous points on which the servants of the undertaking came into contact with the consumers and could thus extend and increase the business. Rather than give up these powers, if they were an obstacle to the co-operation which most of them were wanting to see with the other section of the industry, he would even suggest that any profit which might be made by the undertaking on these sales should be pooled for the benefit of the electrical industry in the area, *i.e.*, supposing the trade discount amounted to 25 or 30 per cent. this amount should be expended by the undertaking for the benefit of the contractors and other electrical industries in that area, and that would show that the municipal undertaking was not endeavouring to filch so called illegal profits from private enterprise, and would generally prove that the whole object of the undertaking was to increase the electrical business in the area in which it worked. He wished very strongly to support Mr. Vignoles in his suggestion of what he might call the Development Committee to be inaugurated by the Association somewhat on the lines of the Electrical Vehicle Committee, which had done such excellent work. There was no question about it that the Association, although working on what some people called narrow municipal lines, had shown the finest co-operative effort that they had seen in the electrical industry for some years past. The Council of the Association had appointed three or four members who could be largely outvoted by the other interests of the Electrical Vehicle Committee, but there was no thought of that because all on the Committee believed that they ought to work for the general interests and not on the lines of municipal or private enterprise. He would

like to see such a committee formed co-opting representatives of other bodies doing or attempting to do the same kind of work, not only manufacturers and contractors, but others interested directly. There were bodies which had a great deal of experience in electrical publicity work whose experience and advice might be of very considerable use. He would like to see a resolution or a communication at this Meeting that the Association generally would be in favour of the Council instituting a Development Committee of that kind on these lines. It was most regrettable that the chief organisation of the industry, the Institution of Electrical Engineers, had practically put on one side all questions of commercial and non-technical consideration. The chief body of the industry was pre-eminently the one most fitted for giving the lead to the industry and the sections of the industry. The Municipal Electrical Association and others forming these various co-operative Committees could not have anything like the same effect—although it was better than nothing—as a central commercial organisation created by the recognised head of the industry. It was a common thing to regret the action of the Council of the Institution of Electical Engineers, but surely the Council of the Institution like all Councils was made up from the membership of the Association, and the business of the members as individuals, if they were not satisfied with the policy of the Council, was to get it altered. The most disappointing thing he had experienced for some time was that at the annual meeting of the Institution of Electrical Engineers—*the* one opportunity of the year when this sort of thing could be ventilated, was afforded—there were ten members of the Institution represented and the only persons present who had anything to say in the way of criticism of the policy of the Council, were two members of Council, one Mr. Hirst and the other himself, who were Chairman and Vice-Chairman of the defunct Industrial Committee. The small attendance seemed to show that the membership generally was in agreement with the policy of the Council, and yet it was perfectly well known that there was a considerable under-current of great dissatisfaction that the chief body of the industry was not prepared to take up that which was the bread and butter of every member of the Institution. If this excellent paper of Mr. Vignoles had the one effect of causing the formation of a Development Committee on the lines indicated, it would be well worth the labour of putting the paper together, and would work 1914 as the year which saw the creation of some development organisation in the electrical industry.

Mr. S. E. Fedden (Chief Electrical Engineer, Sheffield), agreed with Mr. Vignoles in his remarks as to exhibitions and demonstrations. If there was a Grocery or Smoke Abatement Exhibition he always took a stall and exhibited ; indeed, he had provided a permanent stall which could be fitted up at a few hours' notice and be put into bazaars and similar demonstrations. It was only by hammering away that the matter could be put before the public. Regarding Mr. Vignoles remarks as to sales through a contractor, they had had a little trouble in Sheffield from time to time in dealing with contractors, but the department got along very well all the same. The only trouble now was how to effect sales through a contractor ; perhaps Mr. Vignoles would be able to say how it could be done. In dealing with price, Mr. Vignoles stated: "There is a limit, however, and unless the price is at such a level that the consumer is satisfied, no amount of advertising, canvassing or pushing will create permanent business." In this the author had struck a true note, because they must look ahead and see what in a few years time, it would be possible to get for the commodity. For cooking and heating, for instance, they should look ahead and fix the price which was thought would be the one in the future, no matter whether it involved a loss for the time being. The more the apparatus was used, the cheaper it would become, and the better the load factor ; then the price fixed to-day would give a good profit in four or five years time. He had had special experience in this matter in regard to power. In 1902 he fixed a price which he believed at the time was looked upon as too low to be any good whatever. That price with few exceptions held good to-day, namely, 1d. with discounts down to ·6d., the only alteration being the addition of a tariff of £4 per kw. and ¼d. per unit for extra high pressure supply. With that price he had increased his power demand from 2,000,000 units to 26,000,000 units, thus showing that it was a satisfactory price when fixed all those years ago. His experience with regard to the hiring of motors was similar to that of Mr. Vignoles, namely, that there was very little demand for motors on hire now ; consumers preferred to buy them. In order to deal with the small number hired it was only necessary for him to borrow a few hundred pounds a year from the renewal fund or from revenue. Although Mr. Vignoles stated that sales departments were not essential, he (Mr. Fedden), regarded them as most desirable, as he had found it the most satisfactory way of carrying on his business. With regard to the laying of mains, in Sheffield, in any important street they put down two pipes, one to take the immediate low

tension cable for the actual supply and the second to take the high tension 2,000 volt cable, which he believed would be necessary eventually to supply the cooking and other loads which would come on, because with houses taking up to 20 kws. each, they could not be supplied from the low tension mains. He believed there was going to be an enormous development in the cooking load bigger than the power load before long, even in towns where gas was as cheap as it was in Sheffield. In laying mains in this way in Sheffield it was the policy to debit against a particular consumer only the cost of his actual supply; in other words, instead of charging the cost of the big cable laid down in the first instance, even if it only supplied the one consumer, they calculated the cost of the small cable which would be necessary to supply him alone, and if his demand was at all a payable proposition he went ahead with it. In all new streets and in all new town planning districts, he laid mains on both sides of the streets before the streets were made up at all. In this way he had carried out £30,000 or £40,000 of street work for the future, and although it was an attack on the sinking fund at the present day, it was going to be a profitable thing in the future. He was beginning to look upon lighting as a bye-product and as an advertising agent; one of the best that central station engineers had. He did not fear the half-watt lamp at all, because his experience, and also that of many others when the metal filament lamp came on to the market, was that without it they would have lost many consumers who would have continued with incandescent gas. He did not think that even if the small lighting consumer did not pay, this need agitate the management at all, because they were bound to get a lot of small consumers who did pay to every one who did not, and further, the non-paying consumer was a splendid advertising agent, and they were merely paying a little bit for the work he did. They were out to get everybody who would use electricity for domestic purposes whether they were an immediate profit or loss. With regard to heating he had found that the four-light radiator was practically a back number now. Most of his radiators were 3 or 4 kw., and they found a great pleasure now in pushing heating in Sheffield, because they had a fire with which they could knock out gas completely. Some people had not believed it and he had sent out fires to be tested alongside gas fires, and it was not two or three days before out went the gas fires and in went the electric fires permanently. Mr. Vignoles mentioned 15s. per quarter for cookers. He presumed that was a mistake and that it should be 15s. per annum. (Mr.

Vignoles: No.) He thought this far too high a price and did not believe Mr. Vignoles would do any business at it. If he would adopt the principle he had suggested with regard to the cost of power and take into consideration that cookers when they come to be made in larger quantities would be half the price they were to-day—easily half—and if Mr. Vignoles would take the bull by the horns and consider what was going to be in the future, and fix his rental on that basis, he would do much better. He had fixed his rental at Sheffield at 4s. 6d. per quarter and bought a couple of dozen cookers and within ten days they were all out. They were being looked after by the canvassers, and the people were called upon to see if they wished to send them back again, but nobody wanted to get rid of them, and that against gas at 1s. 3d. The only trouble was to get cookers delivered; he could not get them, the manufacturers had not laid themselves out for it.

Mr. E. E. Hoadley (Chief Electrical Engineer, Maidstone), said it had been suggested that 1914 should inaugurate a new era in the business of electricity supply. He sincerely hoped it would. But to a great many of them—he thought he was right in saying most of them—the be-all and end-all of this new era started and finished with whether they could get the powers to hire and hire purchase or whether they could not. Although he was in agreement with getting as full powers as it was possible to get, yet he thought the time had now arrived when they should seriously consider whether it was not best for them to take the powers to hire and hire purchase, and try later on to get the full powers if they be necessary. As engineers they should be able to get over some of the little difficulties that might arise through having to sell through a contractor and through a contractor only, but he did ask the Association to remember as engineers that they were men who were supposed to do something. During the past six or seven years, there had been a terrific lot of talk about getting these fuller powers, and people outside would soon begin to think that they were an association of members of Parliament rather than engineers. It was all very well to say they must reduce their prices to compete with gas for cooking and heating, but even when they got down to ½d., a great many towns were practically helpless because they went to a consumer and endeavoured to convince him that his cooking would cost no more by electricity than by gas, but when they began to tell him that he had got to pay anything from £8 to £10 for a cooker and the gas company was

willing to put one in without charge at 3s. 6d. per quarter the man would be a fool or very keen on electricity if he would pay a large price for the apparatus down. He agreed with Mr. Vignoles in that engineers did not always realise the loss that was entailed in supplying lighting at a low flat rate. Mr. Vignoles was perfectly right in saying that the only proper and sound way to work out the average cost to an undertaking of any one class of supply, was to work it out on the basis of a fixed price and a small running cost. If that were done it would be brought home to a great many that a fixed flat rate of 3¾d. or 4d. was only about one-half or one-third the actual cost per unit of supplying a great many customers such as offices or shops; better class shops in high class districts. He believed it was far worse to supply lighting at such low fixed rates flat than to supply cooking even at less than ½d. He agreed that it was advisable and the right thing to do to encourage contractors; most engineers did encourage them. In Maidstone there were six contractors and they were encouraged so much that if the supply undertaking stopped, the whole of them would go out of business next week. He could not himself remember half-a-dozen jobs that they had got off their own bat. They simply waited for the undertaking to do the canvassing and pass the jobs straight on to them and then see it right through from beginning to end whilst the contractors took their money. Even so, he was perfectly satisfied. He did not want to make a profit on the job, but merely wanted the customer to supply and reiterating what he had already said, he hoped this Convention would mark a new era in this whole business and that they would realise that if it were impossible to get the whole of the powers they wanted, it was absolutely necessary that they should get some of them and especially the hiring and hire purchase, powers.

Mr. A. C. Cramb, (Chief Electrical Engineer, Croydon), said his experience was that to have show-rooms open for only a few weeks or a few months did not produce any lasting effects. It was necessary to have show-rooms open permanently, and it was often two or three years before any real benefit was obtained, and whether they had hiring powers or sales powers, permanent show-rooms must be maintained in towns of any size. A place was necessary where the people in the town could go and obtain reliable information, and he was firmly convinced that a town that had not a show-room made a very great mistake. Mr. Ayton had shewn how cheaply he could run his publicity, but

he did not consider there was any particular virtue in this. He did not believe there was any town in the country spending as much as they ought to do in developing their business. In Croydon he spent £500 a year in salaries on canvassers and staff, and £1,100 to £1,200 per annum altogether upon his publicity department. It must be remembered that there were two points of view; having spent money on services, it was very necessary to hold the business already obtained and to continue to draw revenue from these services, whilst it was also necessary to continue to aim at getting new consumers. Therefore it was necessary to maintain a department to look after consumers and to put them right on any complaints. Reference had been made to starting another Committee with regard to advertising and publicity, and he agreed that some central publicity organisation was absolutely necessary. It was to be remembered however, that in London a publicity committee was started and continued for some time. The municipal representatives however, were not as suggested by Mr. Ayton, thrown out. They were in the position that municipalities could not subscribe to exhibitions and that sort of thing, and it was not fair for them to continue to take part in the deliberations of the committee if they did not do their share in the financial support, and the only graceful thing to do was to withdraw. It was no good forming a committee of the I.M.E.A. until they got the I.M.E.A. Bill through. He did not see how it would be possible to run a central organisation satisfactorily at less than from £5,000 to £7,000 a year, but municipalities could only purchase literature and could not subscribe to the fund under present conditions, and therefore it did not seem to him useful to form a committee from a central organisation without the necessary financial support was forthcoming. Therefore they should concentrate on getting the I.M.E.A. Bill through, and having got it through they could subscribe liberally and so do even better work than the British Commercial Gas Association which had been brought into existence by the admitted activities of electrical undertakings, which however had been stopped by the Local Government Board. Reverting to the question of complaints, a good staff of canvassers was very useful in following up any complaints, and keeping in touch with the consumers until they were satisfied. In his own case every complaint had to be notified to the Publicity Department when it had been satisfactorily cleared up, and a letter was then sent to that consumer stating that the department was advised that the matter had been cleared up to his satisfaction. By so doing a

very efficient check was kept on the publicity staff. Much had been said with regard to contractors; he thought they had had too much of this question of supply engineer *v.* contractor of late years. A great deal of it was unnecessary, and he did not wish to make much of it now, but there were unreasonable engineers and unreasonable contractors. In a large town there were no doubt more reasonable contractors than in other places, and if they got a decently educated contractor he was generally a man who could be brought round to look at things from a reasonable point of view. Central station engineers should look at this matter from the point of view that the contractors were a valuable asset to any undertaking, as they supplemented the business development department, and by having show-rooms in different parts of the area, saved the necessity of having branch show-rooms. It could not be expected that a contractor would work unless he was going to get a profit on the actual installation work. This work should be done by the contractor and the supply authorities should see that it was carried out in a satisfactory manner, but there were portions of the work in which the supply authority must come in, such as the supply of apparatus on hire and the maintenance of outside lamps, etc., things which the gas company were quite prepared to carry out below cost. Therefore there was a great deal to be said in favour of pressing forward for hire and hire purchase powers in the I.M.E.A. Bill, and he did not think at this time of the day they should go on making concessions to the contractor. Large concessions had been made by the Council, but the Electrical Contractor's Association had waited year after year to see how the Bill came out in the ballot, and when they saw there was no chance of it going through, they still maintained their policy of waiting another year. There was a want of sincerity about it on the part of the Electrical Contractors Association which the I.M.E.A. might very well object to, but he did not want to make much fuss about that. Nevertheless, he contended that they should stick to their Bill, and that individual undertakings should go for hire and hire purchase powers. With regard to the general management of electricity undertakings, they all ought to realise now that the head of an electric supply undertaking must really be as much if not more, a commercial man as an engineer. In a job of any large size, the chief officer would only be able to deal with the general run of things, and they must make up their minds that they were running a competitive business and should drop the professional side and go in more for the shop-keeping side.

Alderman Smith (Liverpool) deplored very much the language used by Mr. Seabrook and by Mr. Ayton who described those who were doing their best in the interests of electrical undertakings, as filchers of illegal gains. That was handling chairmen and committee men in a way they did not deserve, and in a way he did not feel inclined to sit still under. In Liverpool they did not mind spending money either to extend their undertaking, support an exhibition, or to further in any way the interests they considered it was their duty to conserve. Then they were asked by Mr. Seabrook not to go on the narrow lines of municipal enterprise. He maintained that those who were responsible for municipal government, took a broad, statesmanlike view of the questions they had to deal with. Yet again Mr. Fedden had spoken of taking on consumers even at a loss. He objected to that attitude of mind. He did not mind facing an expenditure that might not be an immediate profit. He would face it with the object of doing what was their primary duty, namely to get the undertaking sound and efficient, but he would not agree to take on business at a loss. Then Mr. Seabrook had suggested pooling profits with contractors. This he strongly objected to. He was working for the city and not for the contractors, who must look after their own interests. All he wanted to do was the fair thing by contractors.

Mr. Seabrook said that on a point of explanation, he did not say " filching illegal profits " ; he referred to them as " so-called illegal profits."

Alderman Smith said Mr. Seabrook might have intended to say that, but bearing in mind the importance that he himself attached to the observation he ventured to take the words down exactly as they were read.

Bailie Willock (Glasgow) disagreed with the views expressed by Alderman Smith as to utilising the profits of the electrical undertaking for the benefit of the rates. The duty of all municipal undertakings was to provide for the public the cheapest article possible, whether it be gas, electricity, police, cleansing or anything else. They should not rob the water undertaking to help the electricity undertaking, nor the gas undertaking to help the police rate. They should bravely say that their cost for these commodities was so much, and that the charge for it was so much. He objected to the Councils who took large sums from the electrical undertakings for the

relief of rates, and then went before their ratepayers as great financiers. He asked those who shared Alderman Smith's opinion to face this matter fairly and squarely.

Mr. J. Horace Bowden (Chief Electrical Engineer, Poplar) said he knew of no industry which called for greater attention and development in its commercial policy than the electricity supply industry. The manager of to-day in addition to being a fully qualified engineer, had to be a financier, a salesman, a cook, and a good organiser, or else he failed in his vocation. Indeed, the manager of to-day must have a diversity factor of 10 and a load factor of 200 per cent. He objected to the statement in the paper that it was possible to get a consumer to pay more for electricity than for gas. He was prepared to admit that a consumer who really wanted electricity would pay more for it, but what they wanted to get hold of was the man who had gas and was quite satisfied with it. He failed to see how they would get this class of consumer if they did not supply at a price that would compete with gas. Neither did he agree with the statement that there was a considerable profit on public lighting. In Poplar he only charged £9 and a ½d. per unit, and the profit of £700 on about 900,000 units was not a very big item. Nevertheless he contended that public lighting should be supplied at the very lowest possible, just above cost price, as it was undoubtedly one of the best advertisements, and anything which would tend to clear streets of gas altogether was a good advertisement. He would like Mr. Vignoles to give a little further explanation with regard to the cost of services mentioned in the paper. It was stated that in 1906 the cost of service was £3 19s. 10d., and that this had been reduced to £2 17s. in 1913. Did this mean £5 14s. for a double service or was the £2 17s. for the double service ?

Mr. Vignoles : The £2 17s. is for the single service.

Mr. Bowden continuing said that the method was a very good one, but he should have expected a somewhat better result. With regard to cookers he had tried many, but was certainly not prepared to admit that the last word in cooking had been heard. Had Mr. Vignoles ever attempted to charge the £3 per annum he had referred to for a cooker, and had be been able to get it ; to do any business 5s. a quarter would be nearer the mark. He was obtaining quite a satisfactory cooker for an East End borough like Poplar for £6 or £7, and believed he would be able

to do quite a big business with it. As to the financial control, he strongly advocated keeping this as self-contained as possible in every respect. The assessment of the consumer was surely the engineer's job and not that of another department of the Corporation. Mr. Vignoles held very similar views to his own with regard to running costs, the only difference was that Mr. Vignoles arrived at a percentage basis whilst he had endeavoured to arrive at the same thing on a financial basis of figures which could not be altered, and which were fixed at the beginning of the financial year. As to the figures on page 46, of the division of costs, running cost of Coal was given as 75 per cent. and the fixed cost as 25 per cent. If this were correct in any one year, how could it possibly be correct in the following year, provided there was an extension in the business. Assume for example that there was a 20 per cent. increase in the output, the increase would surely be entirely on the running cost, and the fixed cost would remain the same, whilst the percentage of the running costs compared with the fixed would be $21\frac{3}{4}$ per cent. instead of 25 per cent. He would like to know why there was a difference between the boiler house plant and the engine room plant in the percentage taken on running and fixed costs, and finally how could a percentage basis be a fixed basis. In conclusion, Mr. Vignoles seemed to advocate the selling of electricity at $\frac{1}{2}$d. per unit, plus an annual sum. He hoped that the annual sum would be assessed by himself and not by another department of the Council; in either case he would be a very welcome member of that energetic body known as the Point Fives.

Mr. Councillor Crowther (Sheffield) said he was one of those who believed that the whole of the profits of an undertaking, whether it be an electrical undertaking or a tramways undertaking should be utilised for the purposes of the undertaking. They must first of all see that the undertaking was in the soundest possible financial condition, and having done that, profits should be made use of for further extensions of the benefits accruing from its working. The object should be to produce cheap power rather than to relieve rates. This policy put a city like Sheffield in a position to compete more effectively with foreign competition, and this meant the provision of more work for the workers. There were municipalities in England who were utilising their profits to reduce rates, and yet at the same time had to increase their capital in order to make up the amounts so taken, with the object of getting their undertakings in a proper state of efficiency. He held some strong views on

the question of contractors, but he was one of those who would be willing to work hand in hand with the contractors in order to develop an undertaking, but he was not willing to work with his hands tied. He wanted the same rights and privileges to extend and develop as were possessed by a private firm. Mr. Vignoles did not seem to think it necessary to have sales departments. He would like him to go over to Sheffield and ask the Sheffield Gas Company if the showrooms which they maintained were of no use and also to ask any private gas company if they thought it was financially unsound to maintain their showrooms. He personally did not believe this. It was absolutely essential in many cities to maintain them, although it might not be necessary in Birmingham, which was the home of electrical fittings manufacturers. Electrical contractors met with the greatest competition, not from the municipalities, but from those firms who took up electrical work as a side line. They heard at times that engineers were not enterprising, and he was not surprised when he came to look at the private views on municipal trading held by the majority of some committees. The engineers views must of necessity be tinged by the views of those constituting his Committee. Personally he believed, after twelve years' experience of municipal electric supply, that if they got an able man as engineer, and gave him a fair latitude to develop the business, they could depend upon that business being successfully managed. He had come into contact with engineers during these twelve years and maintained that there was no body of men engaged in any enterprise of any kind who were of higher class and better able to manage their business than the electrical engineers of this country.

In conclusion he said they were on the threshold of greater development in electricity supply than they had ever experienced before.

Mr. W. C. P. Tapper (*Communicated*) agrees with the author as to the necessity and importance of publicity work. It cannot be overrated. For many years he has used in Stepney practically all the methods suggested by the author. In addition he strongly favours the showroom where consumers and prospective consumers can see apparatus, etc., in operation.

One very useful method of newspaper advertisement is a series of blocks for lighting, power and heating respectively

with a space provided for a topical paragraph having the appearance of an ordinary paragraph of news, but, of course, directly or indirectly advertising the use of electricity. This is changed weekly. He does not like the author's suggestion of hanging enamelled iron plates to the arc or tramway posts. As a rule these plates are anything but attractive. Mr. Tapper has adopted a handsome design of box advertisement with a glass panel on each side, which is illuminated at night by a flashing device. The glass plates are interchangeable, and are removed from sign to sign periodically.

The author refers to the work of the British Commercial Gas Association, and also of the Electric Supply Publicity Committee. Mr. Tapper shares with the author an earnest desire to see an Electrical Association capable of doing similar work to that of the British Commercial Gas Association.

The Electric Supply Publicity Committee have not succeeded to the same extent as the Gas Association, but it must not be too severely criticised.

That Committee originally consisted of Company and Municipal representatives, but as the Local Authorities could not subscribe to its funds, the brunt of the expenditure fell on the London Companies. The result was that the Local Authorities had to withdraw. The London Companies, for obvious reasons, will not at present spend money advertising electricity for the benefit of other undertakings. It therefore comes to this: the I.M.E.A. must press forward their Bill so that money can be found for the work, after which Municipal Authorities can take effective action.

On the question of hire and hire-purchase, engineers in London are in a very much better position than in the provinces. They have all the necessary powers and in Stepney have taken full advantage of them. A very large business in the hire and hire-purchase of motors and apparatus is being built up, with very satisfactory results.

Cooking apparatus is also being supplied on these terms.

Although at Stepney they have powers to do wiring, they make a practice of employing reliable contractors for the wiring part of the work.

The problem of the small consumer is a very serious one, and as the author points out will be more difficult with the advent of the half-watt lamp in small sizes. In Stepney the annual cost *per account rendered* is about £2. It follows, therefore, that until the *profit per consumer* on the sale of current exceeds this sum a loss is made on such consumer's supply. Mr. Tapper agrees with the author that the reductions in *service costs*, and increase in use for other purposes, is the true solution.

He also supports the author's suggestion for the appointment of a Committee, similar to the Electric Vehicle Committee, to deal with heating and cooking apparatus and development work generally.

Mr. Tapper entirely agrees with the author on the questions of Financial Control, Relief of Rates, Allocation of Profits. His (the author's) argument cannot be too strongly emphasised.

The author refers to the equated payment system. Presumably he means the same system as is sometimes referred to as the "Annuity System." If so, while his argument in this connection is ingenious, Mr. Tapper thinks no auditor will agree with him.

It is certainly a sound policy to buy assets out of revenue, and one which has been encouraged by the Local Government Board. One important argument in its favour is that the money will probably earn anything from 6 per cent. to 10 per cent. in the business, while if invested outside it will be unlikely to earn much over $3\frac{1}{2}$ per cent. There is unfortunately some doubt as to the legality of this procedure under the Electric Lighting Acts.

On the important question of working capital, Mr. Tapper is of the opinion that the clause in the I.M.E.A. Bill, as he understands it, does not adequately deal with the difficulty. As he remembers the clause it allows a new undertaking to borrow for the first three years to a limited extent. But an undertaking twenty years old wants far more working capital than one two years old, and the amount required will go on increasing from year to year. Therefore, if loans are to be allowed they should be in perpetuity, or at any rate for a very long period. In Stepney they mostly adopt the Grimsby alternative, viz. : using a part of their Reserve Fund.

Mr. Tapper disagrees with the author's division of costs. Running costs should only include fuel, oil, waste, water and engine room stores, and a portion of repairs. All else are "standing costs," or, as Mr. Arthur Wright calls them, "preparation costs."

The author's views are, in general, so sound that Mr. Tapper is sorry to note that he gives approval to the policy of charging for *new classes of supply* a price which does not include a proportion of standing charges. It is fallacious to say that because such charges are not incurred precisely when that particular class of supply is developing, none are incurred at all. One has only to assume a sufficient number of such new classes of supply, each requiring development, and together aggregating an output greater than the original supplies which are bearing the standing charges, to see the fallacy and injustice of such a policy. It can only be a temporary expedient.

In conclusion, Mr. Tapper thanks the author for bringing forward so interesting a paper on an important subject, showing what can be done without Parliamentary powers, and appeals to the Council to let no effort be wanting to get the I.M.E.A. Bill on the Statute Book, so that they may set going an effective organisation to carry on this publicity work free from all unnecessary legal restrictions.

Mr. W. E. Warrilow (*Communicated*) would be glad to know what response Mr. Vignoles has had to any ordinary or special soliciting work which he has done in pushing the domestic electric iron. In the examples of posters for various purposes which he shows in his paper, Mr. Vignoles does not include one for electric ironing. Possibly he may have made use of posters and show-cards supplied by the Publicity Committee or certain manufacturers. It seems to him that these posters are deficient in one important particular. He would like to know if Mr. Vignoles has ever received a suggestion that the electric iron can be used by a lady seated at a table. His (Mr. Warrilow's) wife has had an iron for some years, and she argues that its principal merit resides in the fact that she can sit at a table and get through a considerable amount of ironing while so seated. It seems to him that the posters advocating the use of the electric iron should be drawn up to emphasise this important point. With the ordinary iron it seems to be necessary to stand up to the

work because the temperature of the iron is continually falling and great pressure is required to get the work done. With an electric iron the temperature is practically constant, and the weight of the iron can be relied upon, with such pressure as can be applied from a person in a sitting position, for ordinary domestic work. Mr. Warrilow thinks that a poster which would draw special attention to the fact that the housewife can sit down to her ironing would materially assist in increasing the use of these extremely efficient electrical appliances. He believes Mr. Vignoles will agree with him that the lady represented in the poster should be a typical housewife at work in her kitchen with a good pile of washing to handle, rather than a daintily attired female smoothing out a lace handkerchief on a mahogany table top in the drawing-room.

Mr. W. A. Vignoles in reply said he was pleased to see that his suggestion for the formation of a committee to deal with this question of publicity on a large scale, had been received so kindly. He would certainly adopt Mr. Ayton's suggestion and move a resolution at the annual meeting on Friday, when he hoped it would be supported. Mr. Bowden had asked about the cost of services. The paper explained that the cost had been reduced from £3 19s. 10d. to £2 17s. and that was the cost per single service. It had been done partly by standardisation and partly by running one service into a house and looping through the party wall. In that way he had saved a good deal of money. In some workmen's cottages they had run one service into a house and looped into four or five, and that had helped a good deal. Where the revenue received from these houses was only 20s. per annum, the cost of services was very important, and although one obtained the advertising from it as Mr. Fedden had suggested, he personally did not want to make a loss on it if he could help it. He was hoping, however, that even in these small houses he would be able to persuade the tenants that a rateable value system or some other similar system with a fixed charge and ½d. per unit, would be to their benefit, and that he would be able to induce them to use hot plates or cookers.

The President proposed a vote of thanks to Mr. Vignoles for his paper, which was cordially responded to.

Mr. W. A. Vignoles, in his reply (*Communicated*), says: Reading over the report of the remarks made in the discussion on the Paper, and those communicated in writing, it would

appear that the opinions put forward in the Paper are held by a considerable number of Electrical Engineers and Members of Committee.

Mr. Ayton emphasised the necessity for sustained publicity, and there is no doubt that spasmodic work is almost useless. A steady succession of appeals is what is required, so that the average man will think of electricity at the moment when electricity can help him. Mr. Ayton is lucky in being able to use the tram-car windows for advertising purposes, as £50 a year could probably be obtained by letting these to the ordinary advertiser.

The writer disagrees with Mr. Ayton in what he says about pamphlets. If these are well written and illustrated they will be read and kept, for a time at least.

Mr. Tapper criticises the use of enamelled iron plates on lamp-posts, and says that they are anything but attractive. This is possibly true of the average design, but there is no reason why this should be so, as very artistic designs can be produced if the work is placed in the hands of an aritst who understands what is required ; any design that can be produced by stencils is suitable for reproduction on enamelled iron plates.

The opinion seems to be largely held that powers for selling apparatus are desirable, not for the purpose of making additional profits, but so that the undertaking can get into close touch with the consumer. In this connection, Mr. Seabrook made interesting suggestion that any profits made might be pooled for the benefit of the electrical industry in the area, presumably for use in developing the supply of electricity. This is a very valuable suggestion, and one that is well worth while considering in connection with the objections raised by the electrical contractors to the I.M.E.A. Bill.

A good many engineers also hold the opinion that showrooms are desirable. These will certainly be necessary if sales powers are to be exercised.

The recent case at Ilford emphasises the views expressed by Mr. Hoadley that the questions involved by the I.M.E.A. Bill

must be settled by agreement, and the Bill got through at an early date if the industry does not want to play into the hands of the gas companies.

On the question of hiring out, several speakers said that the rate for hiring cookers should not exceed 4s. 6d. per quarter. This is certainly a desirable figure to aim at, but on the present prices for cookers and cost of repairs, a loss on the hire department would be made at this figure, and although the writer agrees with Mr. Fedden that this might be a sound policy if it could be seen that a profit would be made in the course of a year or two, yet if the I.M.E.A. Bill became law, hiring departments would have to adjust their charges to prevent deficits of this kind. This is a point that evidently requires further consideration.

The writer is glad to note that there is a general feeling against contributions being made to the rates, but that all profits should be used for the benefit of the undertaking, so that the price of electricity can be reduced to the lowest possible limit. Undoubtedly the true benefit to an area from the supply of electricity should be looked for not in contributions to the rates, but in the encouragement of industry by the cheap supply of electricity.

All the speakers, who dealt with the point, were in favour of the department being self-contained, the manager controlling the whole undertaking, and advising the committee on all points, commercial and financial, as well as technical.

With reference to Mr. Tapper's remarks about the equated payment system, this is the same as is sometimes referred to as the annuity system. The suggestion made that in considering depreciation, the fact that the amounts shown as actually repaid on the equated payment system are not a true criterion of the amount provided for depreciation, is one that has been appreciated by the chartered accountants who audit the accounts of the Grimsby undertaking. It is, perhaps, difficult to show this matter by strict book-keeping, but it is undoubtedly a point that must be borne in mind in considering depreciation. Another way of looking at it is that depreciation is probably more rapid in the later years of the life of the plant, and on the annuity system this is automatically provided for by the increasing rate of repayment during the life of the loan.

Mr. Tapper thinks that there is some doubt as to the legality of buying assets out of revenue, although he agrees that this is encouraged by the Local Government Board. Though this course is not provided for specifically by the Electric Lighting Acts, the principle is admitted in Clause 7 of the Electric Lighting Clauses Act, 1899, where it states that the net surplus may, at the option of the undertakers, be applied in reduction of the monies borrowed for electricity purposes.

On the question of small consumers, Mr. Tapper mentions that in Stepney the annual cost per account rendered is about £2. The writer understands by this that the cost of management averages £2 per annum per consumer. This agrees fairly well with the cost in Grimsby, Southampton, and other towns. It was pointed out in the Paper, however, that this is only the average cost, and that each extra consumer does not involve this expenditure. If they did, it would be impossible to supply small consumers at a profit where, in many cases, the revenue received is not more than 30s. per annum. In the Paper particulars are given of the way the writer thinks management costs should be distributed.

Mr. Bowden raised a question in the discussion as to the cost of the looped services which have been adopted in Grimsby. In the Paper it is stated that the average cost per service has been reduced from £3 19s. 10d. to £2 17s. 0d. It should be noted that this is the *average* cost of the service. Where a service is looped to another the actual cost of that service is very small indeed, probably not more than 25s. It is not always possible to adopt looping; in the last year out of 400 services it was necessary to lay service cables in about 300 cases, the other 100 being looped either to new or to existing services.

Mr. Tapper criticises the policy of new classes of supply not being charged with a proportion of standing charges. The writer's idea is that this would only be a temporary expedient, as by the improvement in the costs, due to the extra load obtained, the margin of profit would increase, and would in time be more than sufficient to meet any of the standing charges due to the new class of supply.

Mr. Warrilow in his communication asks about electric irons. There has been a very large response in Grimsby to the advertising that has been done on this line, and the contractors in

the town have reaped the whole benefit. One contractor told the writer that he hoped the department would continue to advertise as he was doing good business with irons, he having sold in one year more than 115 irons without any advertising on his own part.

Mr. Warrilow also raises the interesting point as to sitting down to do ironing work. The writer is endeavouring to find out if other people can do their work, or part of their work, in the same way ; if they can, it is undoubtedly a good selling point, and one that should be emphasised in future.

The writer does not agree with Mr. Warrilow that it would necessarily be better in posters to show the typical housewife at work, rather than the lady in the drawing-room ; the aim of a poster is to attract attention and convey a message ; as to how this can best be done is a wide question, and one that can probably be answered in several ways.

It is very gratifying to note the unanimous approval that was given to suggestions made in the Paper as to forming committees on publicity work and cooking and heating. These resolved themselves into the resolution to form an Electrical Development Committee, which was passed at the Annual Meeting. It is to be hoped that this committee, when it gets to work, will be able to do some useful co-operative work, which will benefit not only the supply but also contracting and manufacturing branches of the electrical industry.

Incorporated Municipal Electrical Association.

BIRMINGHAM CONVENTION, 1914.

WEDNESDAY, JUNE 17th.

MEETING AT COVENTRY.

The Association met at St. Mary's Hall, Coventry, and was welcomed by His Worship the Mayor, Councillor S. Bettmann, J.P.

The Mayor said he welcomed the Association to the ancient yet modern city, in the name of the citizens of Coventry, not only as the representative of municipal enterprise, but as the chief exponents of that modern science the exploitation of which was due to the modern development of the industrial world. He hoped the members would find in Coventry, much to interest them, and that the discussion at the Meeting would be useful and bear good results.

The President proposed a hearty vote of thanks to the Mayor for his kind welcome, which was responded to with acclamation.

Design and Operation of Modern Boiler-house Plant.

By S. E. FEDDEN (*Past President*).

Chief Electrical Engineer of the Corporation of Sheffield.

THE subject of the paper "Design and operation of Modern Boiler-House Plant," which I have been asked to contribute, covers a very wide field, and embraces a number of important features connected with the supply of electricity, almost any one of which is of sufficient merit to form the subject of a separate paper, and for this reason I have merely touched upon the cardinal points as a means of promoting a discussion.

(1) Design.

The main points to consider in the laying down of a steam-driven power station, are

(1) Adequate supply of water for condensing purposes.
(2) Ample facilities for dealing with ashes.
(3) Good accommodation for getting in and storing coal.

There is no need to deal with No. 1 as it is beyond the province of this paper.

No 2, however, is becoming a very serious source of expense and concern in large cities, because of the difficulty

of obtaining tips within a reasonable distance of the station. In Sheffield the cost of carting has increased no less than forty per cent. within the last few years.

This increased expense can quite appreciably increase the cost per unit, and when one arrives at a certain point in this cost of removing ashes it is necessary to take into consideration whether it is not worth while to buy a high priced coal with a minimum percentage of ash, say 4 or 5 per cent. instead of the cheaper class of engine slack with its 10 per cent. to 15 per cent. of ash. The author has lately gone to considerable expenditure to deal with ashes.

A lease of a valley adjacent to the power house has been obtained and a steel bridge erected for guard purposes over the main line of the railway. A ropeway 200 yards long has been installed, capable of dealing with twenty tons of ashes per hour. This method of dealing with the ashes was arrived at after investigating the undermentioned alternative schemes, which worked out as follows :—

		s.	d.	
Disposal of Ashes.	Railway	2	9½	per ton.
	Cartage	1	11	,,
	Ropeway	1	3	,,

No. 3. Dealing with the facilities for getting in coal it is advantageous to choose a site having a high level siding, so that the trucks come in straight off the railway over the top of the bunkers, thereby doing away with the expense of installing and running coal conveyors. This should be self-evident as it costs much less to elevate the 5 per cent. to 10 per cent. of ashes, than to handle the full quantity of coal, in addition to the probability of having to lift the ashes again.

Neepsend power-house is arranged on this plan, and the problem looked rather a formidable one, as the author had to cut sheer down sixty feet and excavate approximately 30,000 cubic yards of material. Trial holes, however, had been taken before a decision was arrived at to utilise the site, and it was found that the material was suitable for brick making. The author, therefore, bought a few thousand

bricks and built three Newcastle case kilns, which were used for providing bricks for building a permanent kiln and chimney.

A large portion of the material was found suitable and was converted into bricks for the power house, other portions of the excavations were found to be good hard rock, suitable for concrete and wall building, and the foundations were excellent.

The expensive looking site, therefore, turned out to be a cheap one as regards capital cost, and is proving itself most convenient and economical in maintenance and running charges, and will be more so when the station is finished and the full complement of plant installed.

The capital cost per kw. for the first section of the station is below £10, including the cost of land and sidings.

From the drawings in the appendix it will be seen that although the turbines are widely spaced, the boilers have to be cramped, in order to obtain the necessary amount of steam. The original plan of boilers in line with the engine room had to be amended, and the boilers placed in a transept running out of the original boiler house.

The present equipment of the boiler house consists of eleven water-tube boilers of the following capacities, three more boilers being under construction to be erected for next winter's load.

	Nos. 1 to 4.	Nos. 5 to 8.	Nos. 9 to 11.
Heating surface ..	6,210 sq. ft.	8,016 sq. ft.	9,611 sq. ft.
Grate area	80 sq. ft.	144 sq. ft.	192 sq. ft.
Normal evaporation of water per hour ..	30,000 lbs.	35,000 lbs.	48,000 lbs.
Steam drums	3 of 3′ 6″ diam.	3 of 4′ 0″ diam.	3 of 4′ 0″ diam.
Mud drums	2 of 3′ 0″ diam.	2 of 3′ 0″ diam.	2 of 3′ 0″ diam.
No. of Tubes	432	540	648
Stokers	Bennis.	Chain grate & Underfeed.	Chain grate.

Boiler Feed Pump Rooms.

The boiler house is provided with two pump rooms.
No. 1 contains :—

Four Feed Pumps of the long stroke vertical compound double-acting type, three having a capacity of 3,000 gallons per hour, and the fourth 10,000 gallons per hour.
Three live steam feed water heaters, capable of raising the temperature of the feed water from 85° to 135° F.

No. 2 contains :—

Four feed pumps of a similar type, with a capacity of 10,000 gallons each per hour.
1 rotary feed pump, motor driven, with a capacity of 20,000 gallons per hour.
One motor-driven centrifugal pump, with a capacity of 10,000 gallons per hour. The duties of this pump are of a three-fold nature :—

(1) In the event of the town water supply being cut off, water can be pumped from the river direct to the overhead feed tank.
(2) It can be connected to the existing water service mains where the town supply is not available to provide a supply of water for fire purposes.
(3) Economy is effected by using the river water in place of town water for cleaning out the boilers.

Five live steam feed water heaters.

An overhead tank is fixed above each pump room, the capacity for No 1 pump room being 20,000 gallons, and No. 2 pump room 25,000 gallons.

The exhaust steam from each steam feed pump is led to the overhead feed water tank, the exhaust pipe having a silencer fitted. It is, however, essential that great care should be exercised to prevent oil getting into the economisers and boilers.

Pipework.

The whole of the steam piping is wrought steel lap welded, with cast steel tee pieces. The valves and byepasses are also of cast steel suitable for use with superheated steam.

The steam pipe is 10″ and 12″ diameter single main, and runs the whole length of the boiler house. The turbines

and boilers are connected to the main steam pipe by single connections, and the steam of the feed pumps only having a ring main.

The water mains are of cast iron 6″ diameter with flanges bracketed.

There are two main feed pipes, hot and cold, running the whole length of the boiler house, and these mains are interconnected by valves so that if a fracture occurs either main can be put into commission. Further, the pipes are arranged in standard lengths as far as possible, so that a fractured pipe can be readily replaced. Expansion pipes are provided by means of copper bends in both mains, and additional precautions are made by having copper bends in each branch connection to the boilers and economisers.

The steam and feed water mains are carried on roller supports whenever possible, and sling supports in other positions.

Coal Bunkers.

Provision is made for a three weeks supply of coal opposite each boiler on the siding level, and each boiler has a shoot holding about 100 tons of coal, which feeds by gravity into the mechanical stoker hopper. At the top of these shoots, and, in fact, between all the railway lines over the bunkers, is provided a steel grid to prevent any large lumps getting through. Bottom-emptying trucks are brought directly over these shoots, and, with the exception of trimming from the extreme corners of the trucks, the major portion of the coal is never handled from the time of putting it in the trucks at the colliery until it is taken hold of by the mechanical stokers.

Wagon Traverser.

At the ends of the five railway lines over the top of the bunkers means had to be provided for the transference of

the railway trucks, either full or empty, from one line to the other, and in this connection the author has obtained an exceedingly useful and satisfactory traverser.

It is supplied with a locking catch and stop block and has a working capacity of eighteen tons gross, consisting of four wheeled wagon.

Gauge	4 ft. 8½ ins.
Length of traverser body	15 ft. 6 ins.
Rise from rail to rail	6¾ ins.
Speed of travel	about 80 ft. per min.
Speed of hauling wagons on and off	about 75 ft. per min.

The traverser is of special shallow construction carried on six cast steel wheels, the four outer wheels being double flanged. It is provided with strong ramps at one end only at present, although, when the lines are extended, the stop blocks to prevent wagons overrunning on the other end of the traverser will probably be removed, and spring ramps provided at the other end. The traverser is electrically driven by means of an eight-horse-power two-phase motor running at 700 revolutions per minute on a 200-volt 50-period circuit.

A clutch lever interlocking with the stop catch and rail block is provided so that the main travel gear wheel can be unclutched when the vertical warping drum is being used. This arrangement is such that, before the traverser can be moved on its rails, the stop catch is freed, and the rails on the traverser locked, thereby retaining the wagon on the traverser. Also, in the opposite direction, the stop catch is fixed, thereby preventing the traverser from travelling on its rails, and the rail lock from opening before the capstan can haul the wagons on or off the traverser.

A guide pulley is also provided mounted on a pedestal, and is used in conjunction with the capstan or warping drum as required. A foot lever strap brake is supplied so as to bring the traverser up into position with ease. The operating levers, controllers, etc., are arranged so that they are operated by one man.

During times of emergency, it has been possible, by means of this traverser, to deal with a very large number of full and empty wagons per day.

Coal Measuring Chambers.

The shoots are fitted with measuring chambers and indicating gear, and the coal is led through breeches pieces to the stoker hoppers.

It is frequently claimed that measuring chambers are most inaccurate, but the author contends that this is not so, as the following will show. All the coal in stock is levelled off every month, and surveys by three men from different departments are taken independently of one another, with the result that the difference between the stock as shewn in the stock book obtained by means of the measures and indicators and that obtained by the independent surveys is not very great.

Stock	6,527 tons	Average, 6,489.
No. 1 Man	6,426 ,,	
No. 2 Man	6,461 ,,	
No. 3 Man	6,582 ,,	

Water Supply.

The next important item in regard to a boiler house is the water supply. If good water is not available it should be treated at any reasonable cost before it goes into the economiser or boiler, and if it is very cold, say below 80° F., the temperature should be increased to 110° F., even though live steam feed water heaters are installed to effect this.

Live Steam Feed Water Heaters.

Many engineers argue that warming water by live steam is economical and saves coal, but that has never been proved to the author, although he concedes this, that any loss incurred by heating the feed water by live steam is well and amply repaid in the saving of repairs to the economiser and boiler tubes, and therefore is a saving of capital

expenditure which would otherwise be required for extra economisers and boilers as spares.

The author supports this contention from actual experience.

The live steam feed water heaters which the author has had in use for some years have been those fitted with a patent indented tube. This is made by taking a plain round tube and indenting it in a regular manner at right angles, so that fluid passing through the tube is thoroughly broken up and diverted into contact with a large amount of impinging surface. It is claimed that a tube so indented has increased the heat transmitting properties in excess of an ordinary plain round tube, as the breaking up of the centre core of the tube increases the velocity of the steam through it and keeps the steam in active contact with the copper. I may say that I have had some years' satisfactory use of live steam feedwater heaters fitted with this patent tube.

Boiler House Design.

In dealing with the boiler house itself, this should be made roomy, high, well ventilated and as light as possible, and ample room should be provided both under the stokers and in front of the boilers.

Further, the ash disposal arrangements should be such that the ashes can be lifted from two or three points in the ashes trench, and whether rails, trucks, elevator or suction plant be employed, it is well not to be absolutely dependent on any one of these, but openings should be left in the boiler-house floor covered with plates, so that the ashes can in an emergency be taken away by carts driven into the boiler house firing level or underneath if the lay-out will allow.

Aerial Ropeway.

At Neepsend the ashes are elevated to an overhead hopper and taken away to the tip ground by a bucket ropeway.

This aerial wire ropeway automatically tips the ashes wherever required, as shown in Fig. 1, whilst the empty

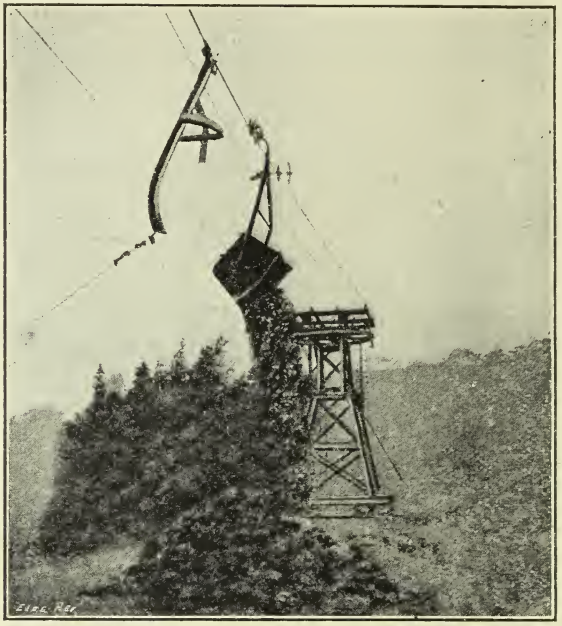


Fig. 1.

carriers proceed onward without stopping or being handled in any way, and are automatically conveyed around the return terminal, as shown in Fig. 2, so that the carriers

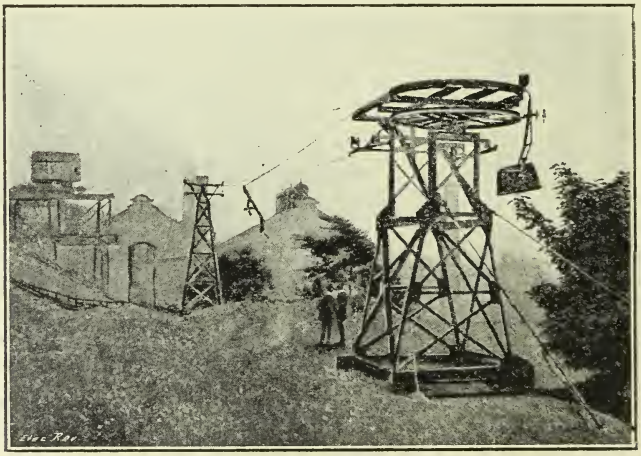


Fig. 2.

are never touched by hand after leaving the loading rail, until they arrive back again at the loading terminal, where they are automatically disengaged from the hauling rope, and then stand ready for loading again, as shown in Fig. 3.

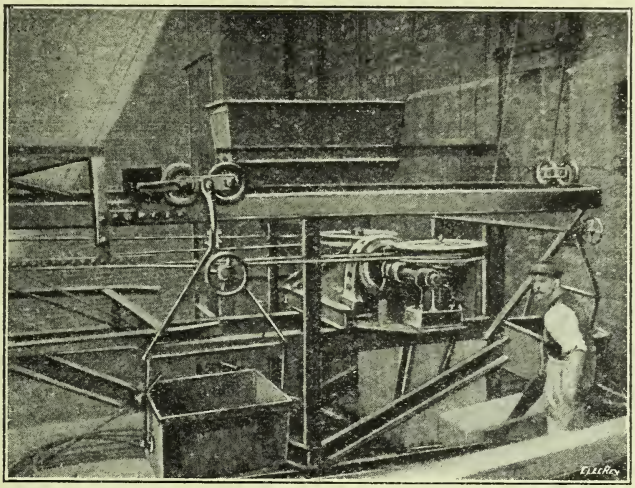


Fig. 3.

In order not to interfere in any way with ground traffic, it was found necessary, in the first place, to elevate the loading rail of the installation to a height of 17 feet above the ground level. The ashes are collected in the basement underneath the boilers in ordinary tipping wagons, each wagon holding $\frac{3}{4}$ cubic yard of material, and running on a light tramway of 2 feet gauge. The wagons are then run to an electric hoist just outside the boiler house, by which they are raised to a height of 40 feet above the basement level. Here the contents of the wagons are tipped into a hopper of 54 cubic feet capacity.

From this hopper the ashes fall through a shoot, controlled by a hand lever, into the boxes of the ropeway carriers standing on the loading rail.

The carrier is then engaged with the hauling rope by means of the patent gripper provided, which conveys the load along the ropeway as shown in Fig. 4, until it reaches the automatic tipper, as already described.

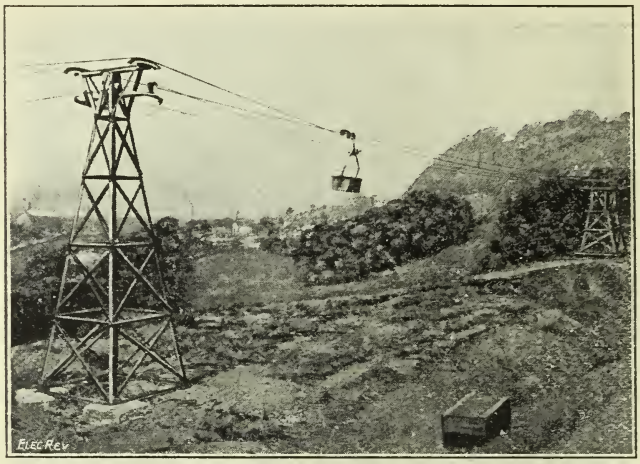


Fig. 4.

The hauling rope, which, of course, is endless, and is constantly running when the ropeway is at work, is driven by means of an ordinary fleeting wheel, which is connected with worm gearing, driven by an electric motor.

The loading terminal is of special design, with a loading rail curved to an exact circle, so that the terminal itself can be readily turned round to face any part of the tipping ground without interfering with its position with respect to the loading hopper, a central pivot maintaining its correct alignment.

The automatic return terminal is mounted on eight steel wheels running on a pair of rails, as shown in Fig. 2, so that as the ground around is filled up in course of time by the tipping, the terminal itself can be moved along. In this

way it will be seen that the whole installation can be moved round fanwise for a total length of 190 feet, so that in time the whole of the low ground to the left of the ropeway will be automatically filled up. The whole of the hauling rope sheaves are mounted on roller bearings, and only occasionally require lubricating, whilst an automatic lubricator on one of the carriers provides for keeping the carrying ropes properly lubricated.

The carrying ropes are of lock coil construction, giving easy and smooth running to the carrying sheaves, whilst the standard (*see* Fig. 2) is provided with White's improved form of rope saddle, giving a long bearing for the carrying rope with easy running of the carrying wheels.

The whole installation, including the loading and despatch of the carriers, is worked by one man, so that it will be seen that the actual cost of disposing of these ashes is exceedingly small.

An additional shoot has been connected to the hopper so that in the event of a breakdown of the ropeway a railway truck can be run under this shoot to give an alternative means of getting rid of the ashes.

Suction Ash Plants.

A suction plant is about to be put in for all new boilers and eventually for the old ones by which the author expects to save considerable labour, and also do away with much dirt and dust besides causing the atmosphere in the ashes trench to be less vitiated by the fumes, also to clean soot from soot chambers and economisers thus reducing the amount of manual labour.

The system of suction plant has been fully described within the last year or two, and I feel there is no need for a further description. However, manufacturers' opinions seem to differ very considerably as to the means of conveying the

ashes and gritty matter by pipes to the receiving chamber. Some recommend a blower of the Roots type, while others recommend a continuous suction by means of a motor-driven fan. A similar difference of opinion appears to exist as to the advisability of introducing a ventilating plant into the suction circuit so as to exclude the fine particles of dust from the vanes or slides which would be quickly scored away.

Selection of Boiler.

As to the type of boiler to be used very little can be said. Circumstances force careful engineers to use practically one of five or six types in this country, and of course these are of the water tube type, Lancashire or marine boilers being totally unsuitable for obtaining the large amount of steam required on the small area available in a modern power station, besides the saving in land, buildings, steam piping, etc., resulting from the use of the water-tube type

There is very little to choose between them; they all want good water, one claims a little better efficiency, the other claims less maintenance. The author thinks that from experience the boilers made in this country are of first-class design and workmanship, and with due care the cost of maintenance should not be heavy. The author is in favour of the vertical tube boiler, having experienced very good results from this type but other engineers have no doubt obtained equally good results from the horizontal tubed boilers.

The aim of all engineers is to get the maximum evaporation out of the smallest floor space. This means a large grate area and the burning of as much coal as possible per square foot of grate area.

There is, of course, an economic limit to this high rate of combustion both as regards efficiency and maintenance, but it is very comforting to feel that boilers can be pushed

to 40 or 50 per cent. above their normal working load in case of emergency. In the event of a very high rate of combustion becoming general and proving itself satisfactory there will have to be a re-designing of the boiler combination by the adoption of larger economisers, superheaters, flues, feed pipes, steam pipes, fans, coal bunkers, ash disposal arrangements.

However, the size of the boiler and the amount of steam required per square foot of ground is governed to a certain extent by circumstances, and the money available for the installation, and engineers must consider each case on its merits.

If land is scarce an economiser raised above the outlet damper of the boiler has much to recommend it, as of course there is then no check to the natural flow of the gases. As an offset to this, however, additional expenditure is incurred in steelwork to support the economiser, and also in the building of a high boiler house, and it may cause a considerable reduction in the capacity of the overhead coal bunkers.

The author considers with his present knowledge that the best overall efficiency and least maintenance cost is obtained by running the following combination :

Water-tube boilers.
Economiser.
Chain-grate stokers.
Induced fan draughts.

At 25 lbs. of coal (rough engine slack) per square foot grate area.	
Evaporation per sq. ft. of heating surface	5·25 lbs.
In-going gases to economiser	450° Fah.
Out-going gases from economiser	300° Fah.

though it is quite possible to burn the same class of coal up to 30 lbs. per square foot of grate area with good economy.

Rating of Boilers.

With regard to the rating of the water-tube boilers it is a matter of common knowledge that the rate of evaporation in the neighbourhood of the furnace is very high compared

with other parts of the boiler. As the rate of combustion increases so does the rate of evaporation with the same size of boiler. The author has noticed that manufacturers have put forward for different capacities similar sizes of boilers, but with stokers having a larger grate area so that some standard as to rating should be adopted. The standard adopted by the electric supply department at Sheffield is that the normal evaporation should be obtained by burning 25 lbs. per square foot of grate area with a chain grate stoker burning engine slack.

The author has lately installed some 8 feet, Class E. underfeed stokers to two water-tube boilers fitted with both forced and induced draught. The boilers were specified to evaporate 35,000 lbs. of steam each from and at 212° Fahr. The combination is as follows :—

Water-tube boilers.
Economisers.
Underfeed stokers.
Induced draught fan, H.P. on load 55, giving 1·3″ draught.
Forced draught fan H.P. on load 30, giving 2″ draught.
Normal coal per square foot of grate area, 33·5 lbs.
Evaporation per square foot of heating surface, 5·25.
In-going gases to economiser, 518° Fah.
Out-going gases from economiser, 290° Fah.

The results are: Burning up to 47 lbs. of coal per square foot of grate area under the above working conditions the boiler evaporated 58,000 lbs. of water per hour from and at 212° Fahr. but the heat of the brickwork was so intense after the first hour's run that the rate of burning was reduced to 38 lbs. per square foot of grate area.

The superheater was not designed to deal with this large amount of steam the temperature being reduced from 150 under normal conditions to 110° Fahr.

The author thinks that this combination has a great future before it and its limit will be determined by the ability of the brickwork, etc., to withstand the intense heat generated in the furnace with the above conditions.

Another important consideration is the form of draught to be employed.

Natural, Induced, Pratts or Forced.

There are many claims that the natural draught system is the right and most economical one, but it lacks flexibility, and makes it so dependent on atmospheric conditions, good coal, etc., and many instances are recorded where generating stations have been started with high brick chimneys, where at a later date fans have had to be added to secure the necessary flexibility and draught.

The author is a believer in mechanical induced draught, and when considering the problem strongly advocates that care should be exercised to install a fan or fans capable of dealing with the worst atmospheric conditions and of dealing with sufficient gases for the maximum possible overload of the plant.

Regarding the hot versus cold air systems of induced draught it would appear that the latter should be the more economical, owing to the smaller power said to be required to deal with the lesser volume.

The author investigated this matter some three or four years ago, but could not satisfy himself that there was any very great benefit to be derived, besides which the cold air injector was expensive to manufacture and renew.

The author is hoping to hear in the discussion the actual experience of users of this system.

Mechanical Stokers.

A decision with regard to the type of mechanical stokers is difficult to arrive at. The ideal stoker should be able to deal with clean nuts or smudge, should be able to get to full duty from banked fires in the shortest possible time, should

be capable of doing 50 per cent. above its normal duty for short periods in case of emergency, should consume all combustible matter fed on to it with the most efficient percentage of CO_2, should be smokeless under all conditions, besides which it must be strongly built, reliable, and easy of access for the repair of the working parts or the renewal of the bars.

These conditions are, of course, difficult of attainment in one stoker. For small grates there are many good and reliable stokers on the market in Britain, but with the larger grates now required the choice is focussed down to two or three. The chain grate has in the past done yeoman work, but it has its weak points, such as the difficulty of burning mixed slack and the difficulty of keeping an even covered grate, the prevention of unburnt coal being dumped, the extra labour in handling riddlings which filter through the grate before coking takes place, and it is unable to comply with many of the requirements set out above. However, when the improvements now being carried out on it are perfected and prove satisfactory in working, no doubt it will come much nearer to the ideal. The underfeed stoker, which has recently been enlarged and strengthened in its mechanical parts, has proved itself, from the author's experience during the last eighteen months, most satisfactory, and complies more nearly with the conditions beforementioned.

The author therefore considers that the safest arrangement for a large boiler house is to install a certain proportion of the old reliable chain grate, which has proved satisfactory over a long series of years, and the remaining portion of the newer type, which, while being excellent from results obtained in a comparatively short time, has yet to prove its superiority over a longer period.

I believe our President will have some practical and valuable information with regard to the two classes of stokers I have mentioned.

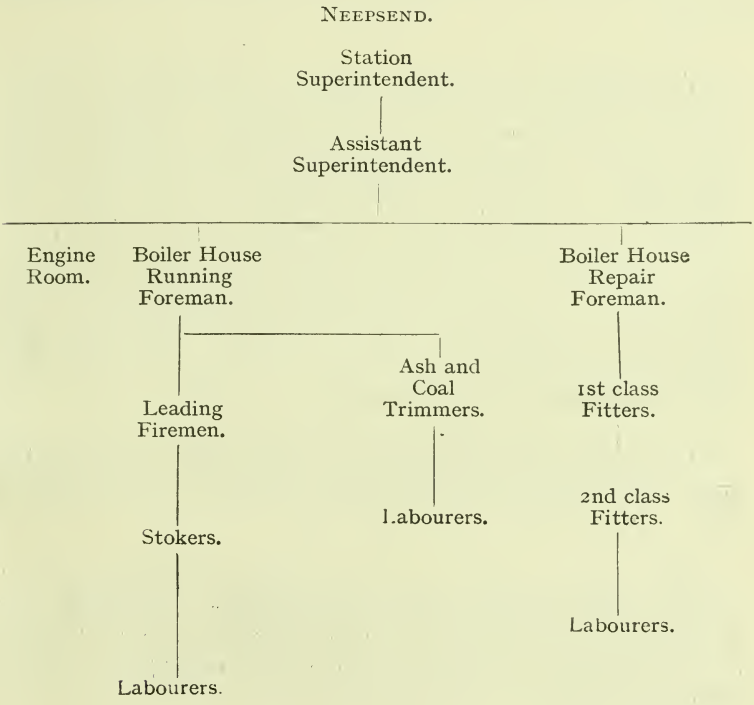
Operation.

The chief points to consider in the operations of the boiler house, are :—

(1) Organisation.
(2) Coal.
(3) Water.
(4) Maintenance of Plant.
(5) Operating costs.
(6) Records, tests.

Organisation.

Dealing with the first point the following chart gives an arrangement which the author has found to work efficiently when the total evaporation is approximately 250,000 lbs. per hour.



The duties of the superintending staff in the boiler house are as follows :

The *boiler house foreman* is responsible for the efficient working of the boilers, and takes daily records of the coal consumption and water evaporation, temperature of flue gases and CO_2, records and makes periodical tests on the boilers.

The *boiler house repair foreman* works in conjunction with the boiler house foreman, and is responsible for the quick repairs to the boilers, superheaters, stoker and economisers, feed pumps and other auxiliary plant.

A chemist is now engaged to carry out all boiler house testing.

Store Coal.—All coal delivered to the station is weighed on a weighbridge and either deposited in the coal shoots, bunkers, or sent to the coal storage ground. At the present time there are 3,000 tons immediately over the boilers and 5,000 tons on the coal storage ground. The method of storing coal depends on the quality. The author has experimented with various qualities and finds that rough slack obtained in the Yorkshire district and stored in large quantities is subject to spontaneous combustion. Consequently nothing but screened nuts are now being laid down and stored in 500 ton lots. The heaps are ventilated and temperatures taken regularly.

In this way it is anticipated the coal may be left in the open for a period of years, and that the loss of calorific value will be only 10 to 15 per cent.

With regard to the method of dealing with the coal for storage considerable capital expenditure is entailed for handling, and is a matter to be considered in the near future by all engineers in order to cope with emergency caused through strikes.

The author has considered schemes and the capital expenditure works out at approximately 15s. per ton of coal stored to about six feet high. If, however, a better class of fuel be purchased and the height increased the cost will be proportionately less.

This 15s. per ton of coal stored includes for the provision of a complete scheme for delivering the coal from the wagons on to the storage ground and back again into the coal bunkers over the boiler.

Another system of storing coal where spare ground space is limited is to erect a silo and install the Clayton or some similar system for extinguishing fire.

A silo can be built to contain two or three thousand tons of coal, and, after filling it, the entrance manholes must be made air-tight. Through the silo pass two main pipes from which branch pipes can be taken as required. These main pipes connect up to an installation consisting of a generator cooler, blower and engine. The blower driven by the engine draws air from the silo along one of the main pipes into the generator, where the oxygen of the air combines with sulphur by combustion and forms a mixture of nitrogen and sulphur dioxide. The gas is drawn through the cooler into the blower, which then forces it along a main delivery pipe back into the same compartment from which the air is drawn by suction. The suction and delivery of gas proceed simultaneously and as the volume withdrawn is equal to that delivered there is no leakage beyond what is due to diffusion.

For the extinction of fire in the silo it is not sufficient to merely fill up the silo with inert gas ; efficient means must be taken to get rid of the large amount of heat which the coal will hold. By this system, after the fire has been stopped by the introduction of gas, the generator is cut out of circuit

and the gas-laden atmosphere circulated by means of the suction and delivery pipes through the cooler, until the temperature of the coal is brought down to normal. Fresh air is then admitted whilst this cooling process is continued, so that the gas is gradually dissipated and re-ignition prevented.

Experiments are also now being carried out to see the effect of turning a portion of the flue gases into enclosed bunkers in which coal fires occur.

The coal is purchased to a rigid specification, and if the calorific value on delivery is below the specified amount a corresponding reduction is made in the price.

Water.—The water is measured by a recorder and this instrument is placed between the overhead hot well and the pumps, so that the records are obtained of the total water evaporated. Similarly the water used by the turbines is recorded, and the difference in the two readings gives the loss, after making allowance for water returned from steam traps and the exhaust from the feed pumps.

Frequent tests are taken to ascertain the hardness of the water, and the degree of concentration in the boilers. No softening plant is required as the supply for make-up contains only 3° of hardness and this figure is generally less in the winter season.

Maintenance of Plant.—Complete records are kept on a card system as to the cost of maintenance of each boiler complete with stoker, superheater, and economiser.

Operating Costs.—The following is a copy of the weekly costs sheet used in Sheffield, the figures being the actual figures obtained for the week named.

CITY OF SHEFFIELD—ELECTRIC SUPPLY DEPARTMENT.

COMPARATIVE STATEMENT OF WORKS COSTS—Week ending 30th April, 1913.

Particulars.	Neepsend				Sheaf Street				Combined Stations.			
Units generated	532,500				33,170				565,670			
	Tons.	Cwts.	Qrs.									
Coal—Neepsend	634	—	—									
Sheaf Street	77	5	3									
	711	5	3	£ s. d.	Cost per Unit.	£ s. d.	Cost per Unit.		£ s. d.	Cost per Unit.		
				240 7 10	·11	35 8 2	·28		275 16 0	·12		
Ashes				10 17 8		2 18 8			13 16 4			
	Gallons.											
Water—Neepsend	78,260											
Sheaf Street	120,700											
	198,960			2 2 6	·00	3 4 3	·02		5 6 9	·00		
Oil, Waste, and Stores				4 14 9	·00	4 0 10	·02		8 15 7	·01		
Salaries and Wages				76 15 7	·03	29 18 7	·22		106 14 2	·05		
Engine Room Equipment				—		1 8 8			1 8 8			
Boiler House Equipment				25 11 5		5 4 4			30 15 9			
Buildings				1 11 4	·04	—	·07		1 11 4	·04		
Sundries				3 18 4		—			3 18 4			
Lighting and Power				59 19 9		3 3 11			63 3 8			
Total Works Costs				425 19 2	·18	85 7 5	·61		511 6 7	·22		
Maximum demand — K.W.				8,331		1,611			9,942			
Load Factor — $\frac{\text{Units} \times 100}{\text{Max. Load} \times 24 \times 7}$				38·05		12·26			33·87			
Current used on Works				23,527		807			24,334			

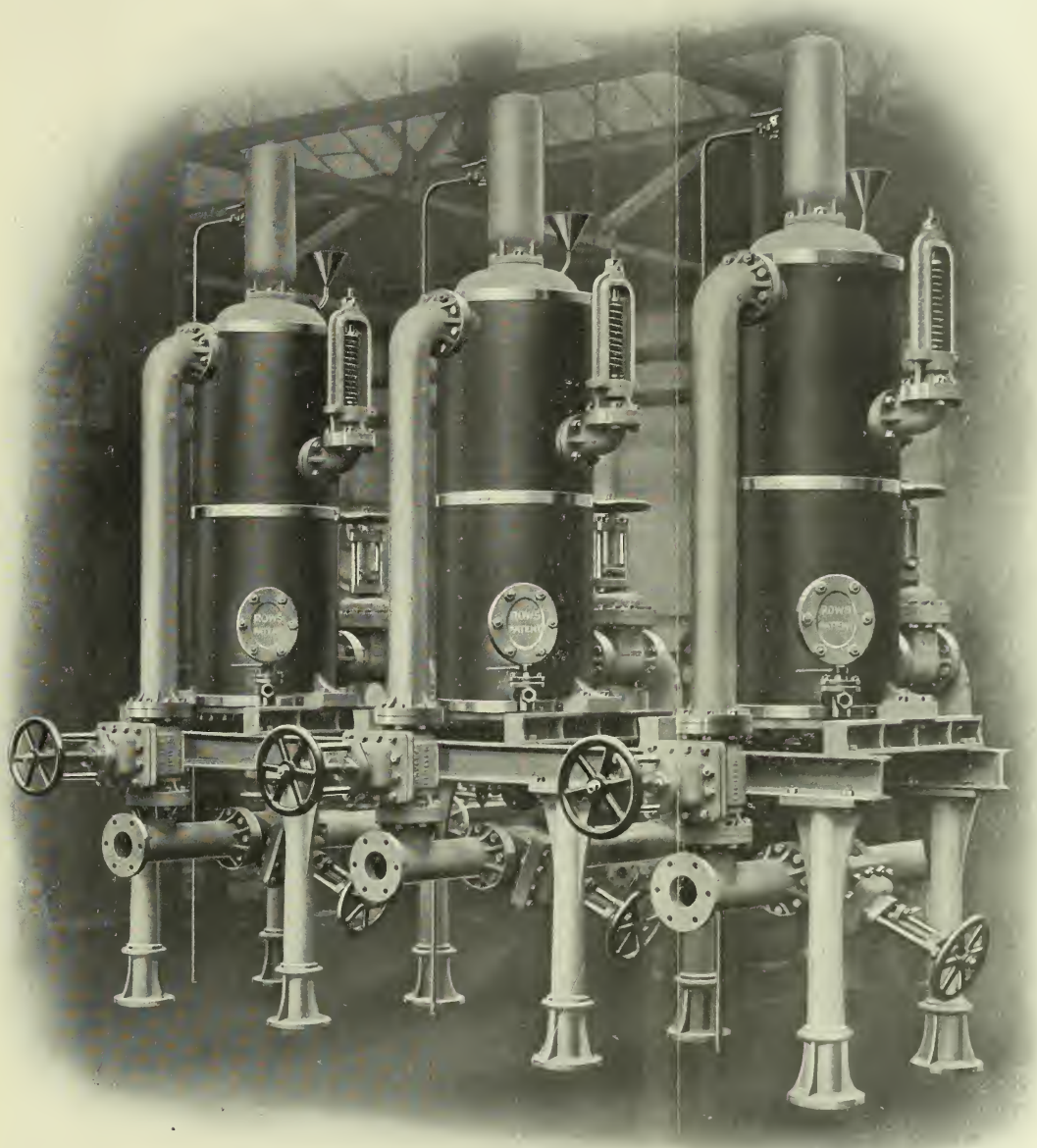
With regard to the suggestion made from time to time lately, that large electric power stations should be equipped with by-product plants, it will, of course, be necessary to bear in mind, that if such plants were installed for distilling the coal and making gas either for burning under the boilers or for driving a gas engine, the capital expenditure per kilowatt of plant installed would have to be considerably higher than it is at present, in an ordinary coal fired steam turbine station. In view of this larger capital expenditure, it will be necessary to carefully arrive at the percentage of the total plant, which could be economically operated by means of the fuel obtained by this by-product plant.

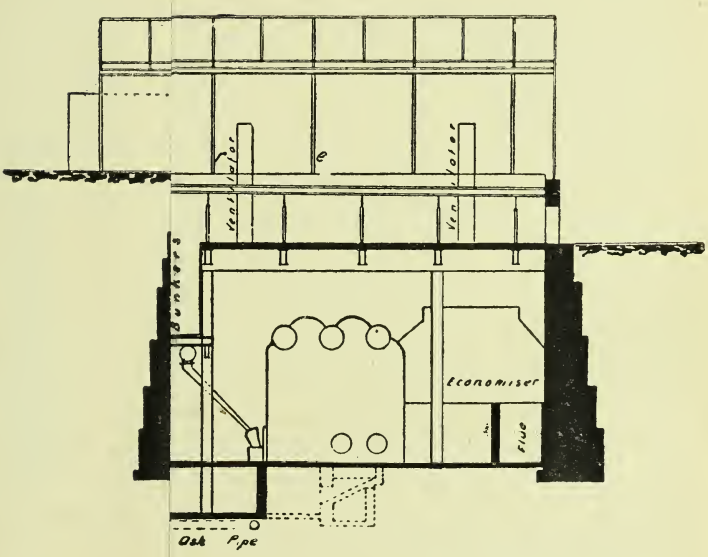
In looking through his present load curves, the author arrives at a figure of 2000 kw. of plant installed out of a total of 25,000 kw. It would appear, therefore, other things being found satisfactory, that it might be economical to provide by-product plant for about 8 per cent. of the total plant of a power house and this plant should be run at practically 80 per cent. load factor to make it a paying proposition.

Of course, if such a thing as by-product plant be attached to a power station, a much larger area would be required, and this in many places would be difficult to find with the requisite facilities as regards, water, coal, etc.

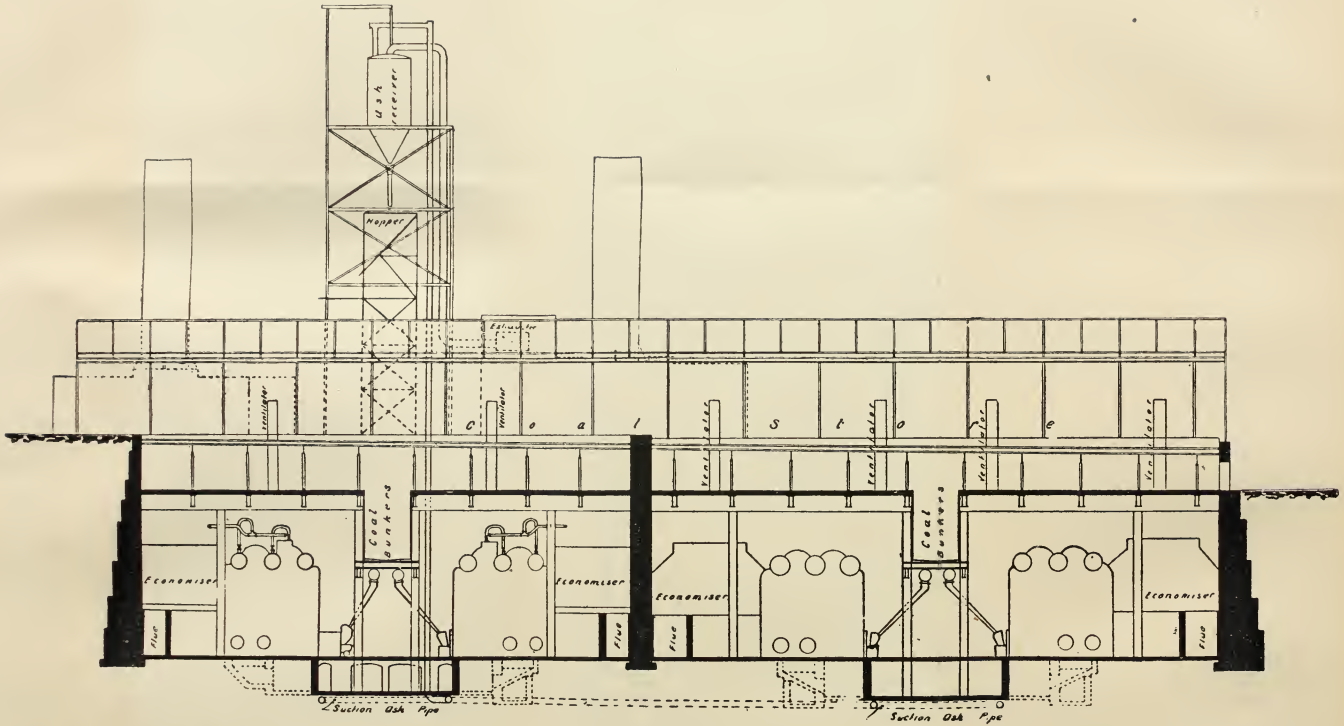
The problem of high superheat is looming in the not very distant future, and engineers and manufacturers will have to face a new set of conditions, when a dull red gas is being passed through the steam pipes and valves.

Finally, the author wishes to impress on all the great importance of a present-day boiler house and plant ; it is, in fact, of paramount importance, where more money can be saved than anywhere else in a power station, by employing and paying highly-trained and capable men who can bring scientific knowledge to bear on the many important problems that present themselves for investigation.



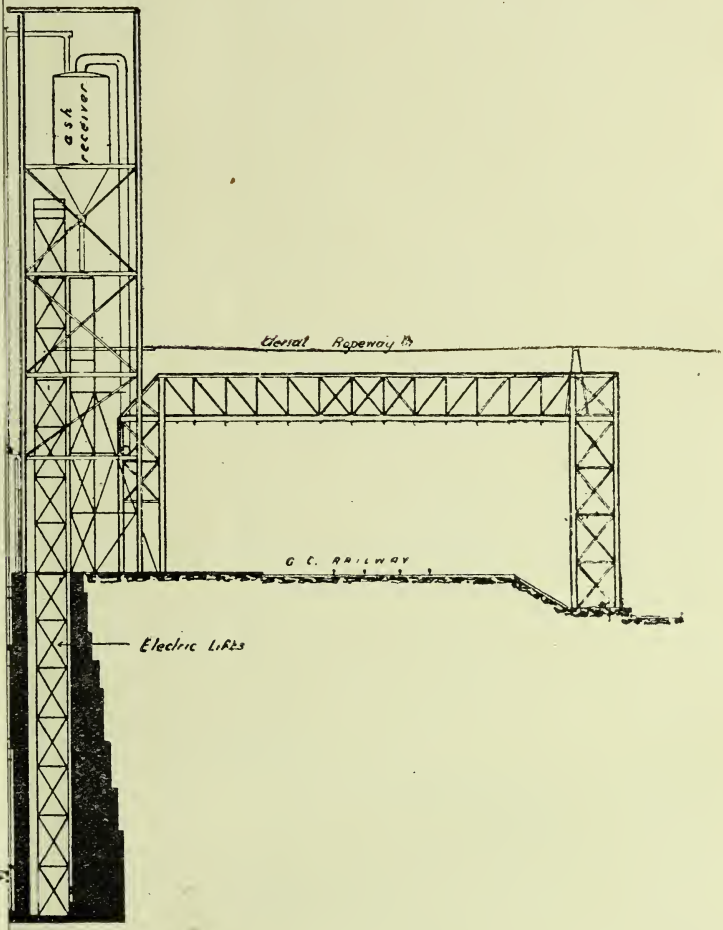


S. E. Fedden M Inst C.E
GENERAL MANAGER & ENGINEER



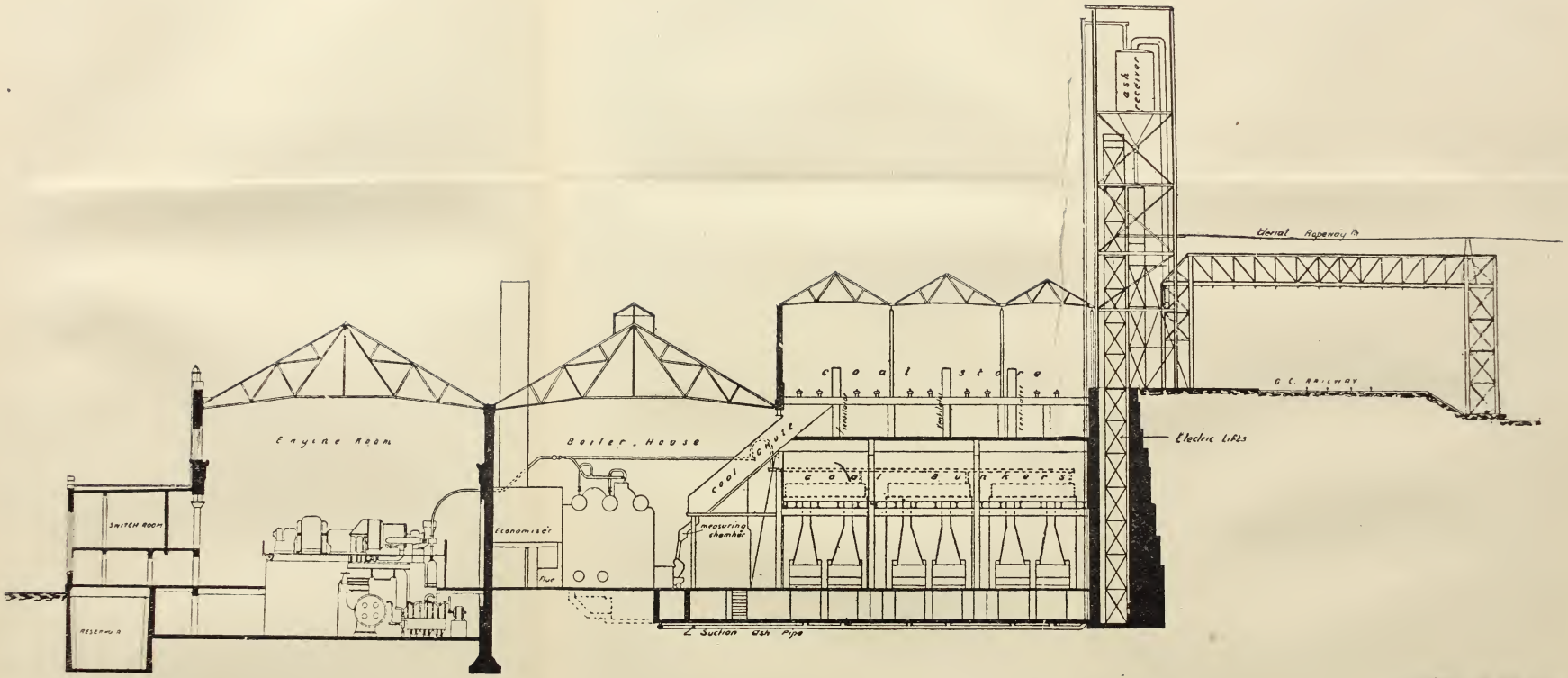
SECTION BB

S E. Fedden M Inst C E
GENERAL MANAGER & ENGINEER



S E Fedden M Inst C E
GENERAL MANAGER & ENGINEER

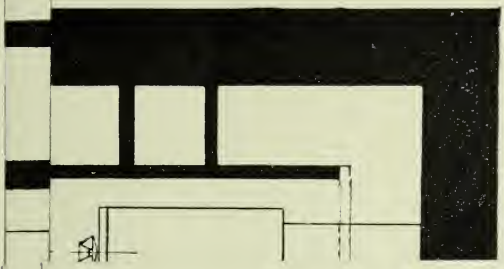
10 30 60 70 80 90 100 FEET
1/8" = 1 Foot



S E Fedden M Inst C.E.
GENERAL MANAGER & ENGINEER

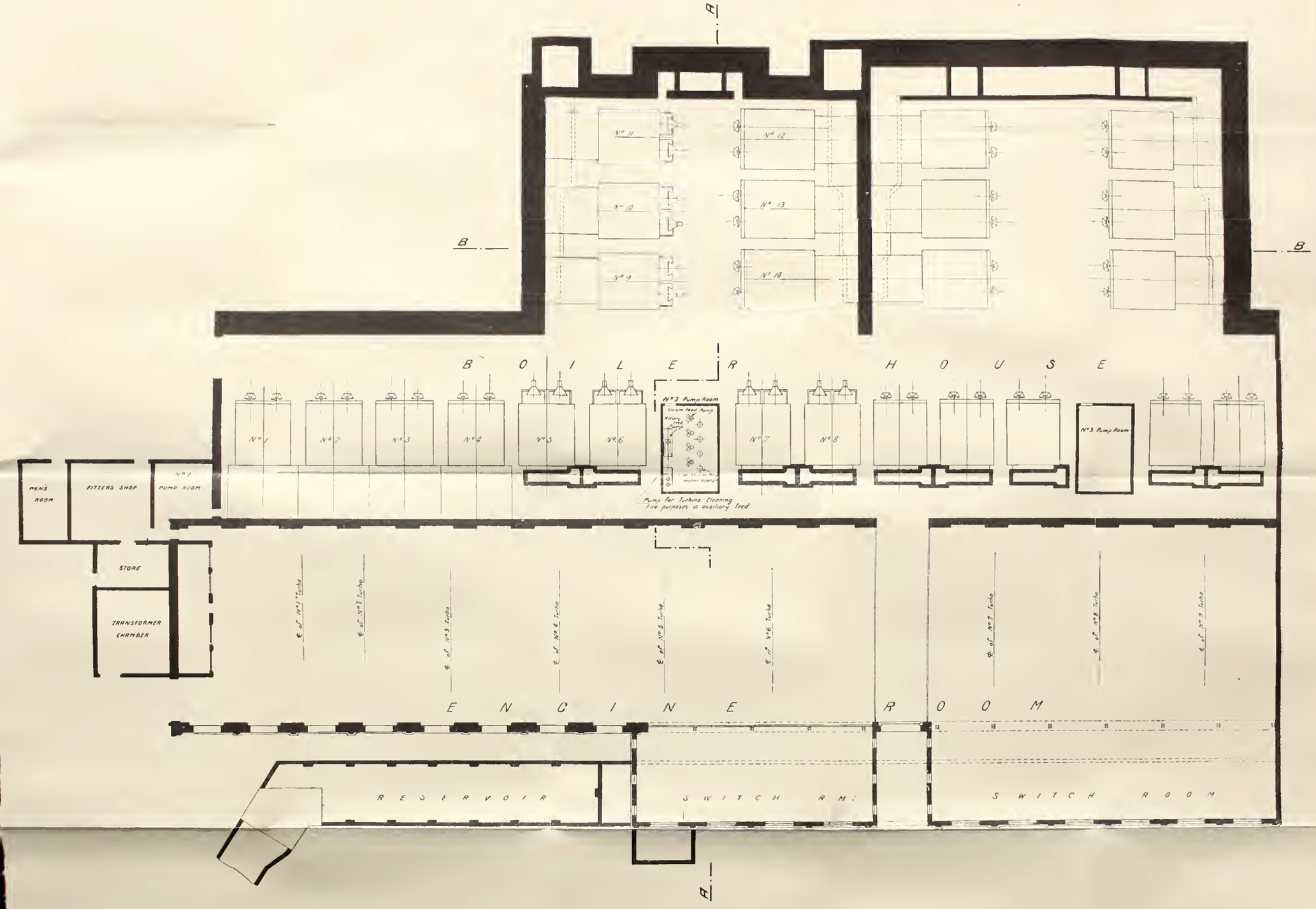
SECTION AA.

Scale ½" = 1 foot



70 FT

S. E. Fedden M. Inst C. E.
GENERAL MANAGER & ENGINEER

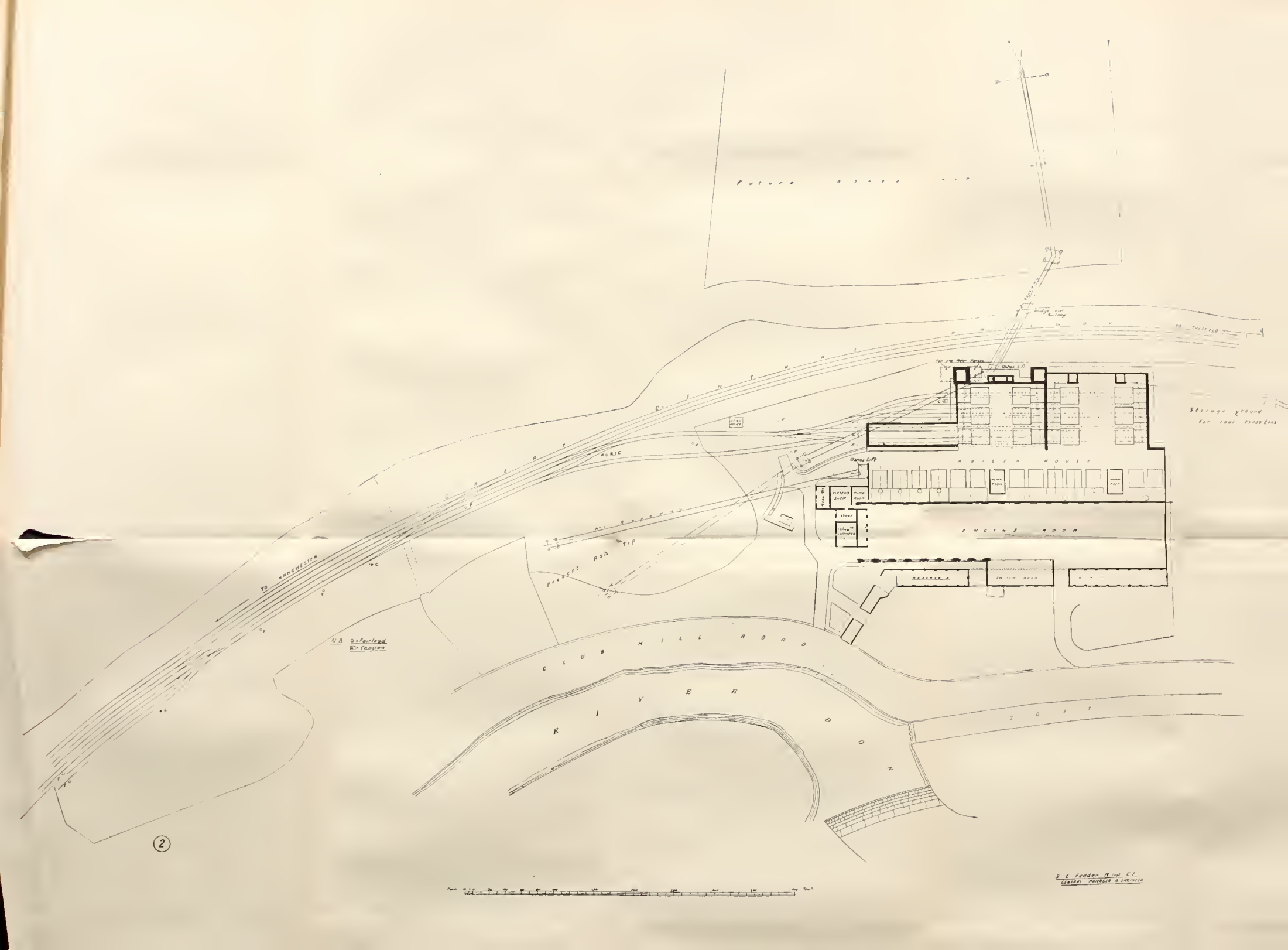


G R O U N D P L A N

FEET 10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 FEET

Scale 1/16 = 1 Feet

S E Fedden M Inst C E
GENERAL MANAGER & ENGINEER



S. E. Fedden M. Inst. C.E.
GENERAL MANAGER & ENGINEER

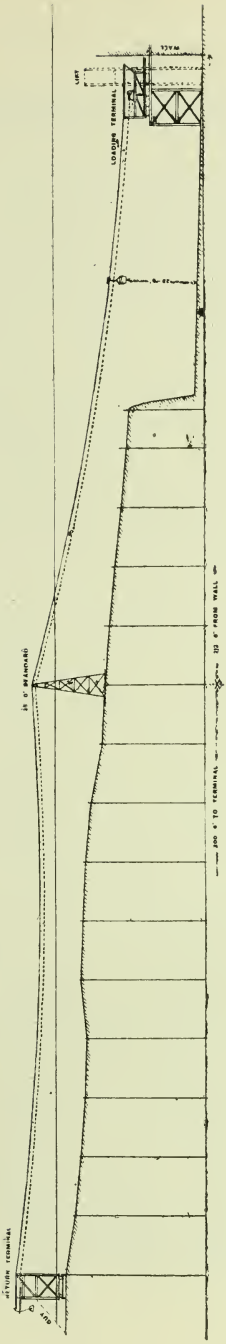


FIG. 5.

DISCUSSION ON MR. FEDDEN'S PAPER.

Mr. W. W. Lackie (Chief Electrical Engineer, Glasgow), in opening the discussion, said that last year he had the advantage of paying a visit to some of the largest electricity undertakings in Canada and the United States, and there he saw some very large generating stations. The conclusion he came to was that the modern boiler house was no longer a stokehold, but a boiler room, in the same sense as an engine or turbine room. By this he meant that the boiler house must have an ample supply of natural daylight, and there should be a minimum of the dirt, dust and darkness generally associated with the handling of coal in a boiler house. The building should be at least of three storeys ; the ground floor should contain the ash and soot handling plant ; the first floor should contain the boilers proper ; and the upper floor should contain the economisers. This kind of building was absolutely necessary now in view of the fact that the size of the boiler house unit cannot be increased in the same proportion as the size of the steam plant unit has been increased. His experience was that the larger the boiler unit one could obtain, the better for all purposes. Until recently they had been accustomed to boiler units with a little over 4,000 square feet heating surface, and if dark clouds or any other necessity arose for a large supply of steam at short notice, it was very comfortable to have one or two boilers of 8,000 or 9,000 square feet heating surface available with steam up. They had found such boilers to be more efficient, and one man could look after a combination of such boilers as easily as he could look after the same number of smaller boilers. They had proved recently in Glasgow that nothing but steel should be used in steam pipe lines. The crown head valve on a boiler burst while the boiler was in commission, and if another valve had not been in series with the faulty one and in such a position that the steam from the main range could be cut off, serious consequences would have resulted. The Board of Trade Inspector made a thorough investigation into the possible causes of the mishap, and it was quite clear in his conclusion that the trouble had been entirely due to superheat and that steel was the only adequate safeguard against the recurrence of such an accident. Mr. Fedden referred to bottom emptying trucks. These are practically unobtainable in Scotland, and this fact added to their difficulty in getting the coal out of the wagons. Coal-measuring chambers had been found by them to be quite unreliable, and they used nothing but automatic weighing machines, one to each boiler. A few

steam-driven auxiliaries, he contended, do away with the necessity of live steam feed-water heaters. The last coal strike demonstrated the necessity for having a large store of coal. In his opinion the stock of coal on hand should always be at least not less than the equivalent of a two-months' supply, and he believed it would pay to have even a larger supply than this. The storage accommodation should be such that instead of taking in a larger quantity of coal in the winter months and a comparatively small quantity in the summer months, uniform deliveries should be taken all the year through, and, if anything, a larger supply during the summer months. The modern boiler house should be and can be equipped with recording and indicating instruments to show the amount of coal burned, the amount of water evaporated, the steam passing to the generating plant, the draught, and in every way to have an equipment parallel and equivalent to the switchboard instruments in the engine room. Five years ago, at the time of the great trade depression, the question of economy in coal consumption was forcibly brought home to everyone. They in Glasgow realised that their coal consumption per unit was very much higher than it should be. They immediately set about installing a considerable number of indicating instruments. These, along with special tests which were carried out, resulted in a saving in the coal bill for the year of some £10,000. This was practically 20 per cent. of the total cost, and it could not be said that reasonable care had not been given to the work of the boiler house in previous years. The wear and tear of bucket conveyors for the removal of ashes was so great that these conveyors were being abandoned. Recently he had installed a suction ash-plant, which had been in operation with most satisfactory results for six months. The cost of operating the suction ash-plant worked out at about five units per ton. This might seem a large figure, but against it must be set the reduced cost of maintenance on moving plant and better conditions for the men. He noticed that Mr. Fedden recommended the combustion rate of 25 lbs. per square foot of grate area in boilers. It might be interesting to quote a test he made recently in one of their stations. He had taken four hand-fired boilers, supplying a 5,000 h.p. turbine, burned coal at 30½ lbs. per square foot, and generated 21,600 units. The lbs. of coal per unit were 3·41. He put on a fifth boiler and reduced the coal burned to 21 lbs., and the lbs. of coal per unit were 3·03—a reduction of 5½ per cent., the draught in both tests being 0·4 water gauge. In his opinion it was not justifiable to work at these rates during the winter months at

time of peak load. In order to keep down capital expenditure it was advisable to press the boilers much higher than the above rates. In working out the cost per kw. hour, it should always be given as so many lbs. of coal per unit, and the calorific value of the coal stated, or, better still, the number of British thermal units per kw. hour. This was very clearly demonstrated in the paper read before the Institution of Electrical Engineers by Mr. Hadley on the Rand Stations. With reference to the question of equipping the power station with by-product plant and firing the boilers with gas, it had been stated on good authority that with coal below 10s. per ton, it would pay to do this on something like 8 per cent. of the total plant, with a 20 per cent. load factor in the power house; but with coal above 10s. it would not pay, owing to the enormous capital cost and area of ground necessary. One of the objects of his visit to America was to see how they tackled emergency peak loads or sudden demands due to fog or black clouds, more especially in Chicago and New York. It was true they had batteries which they could put on to the central area of the city, but the major portion of their lighting, and certainly the whole of their lighting in outlying districts, was on the alternating current supply, and the battery was useless to meet this. He was shown the Taylor stoker, which had been fully tested and responded to sudden demands in a most remarkable manner. He was so much impressed with this stoker that on his return he got the Electricity Committee of Glasgow to agree to equip two boilers with it. The stokers are put under boilers, which normally evaporated 24,000 lbs. of water per hour, and the guarantee for flexibility which the manufacturers of the stokers have given is that, when the fuel bed of the stoker is maintained in a live banked condition, an interval of not more than 10 minutes would be required to bring the boiler up to the rate of steaming corresponding to an evaporation of 24,000 lbs. per hour, and not more than an additional 5 minutes to bring the boiler up to a steaming capacity of 46,000 lbs. The combined efficiency at 24,000 lbs. is 72 per cent., and the stoker should be capable of burning sufficient coal to evaporate a maximum of 58,000 lbs. of water per hour. It was not their intention to run the boilers at these high rates for any length of time, but only to give sufficient time to get other boilers under way. In Glasgow and other large cities they were troubled with this question of sudden demands, especially during the summer, when a considerable number of the boilers were out for survey. The two boilers were now being equipped with the Taylor stoker. A second series of tests would be made in the course of the next month, previous tests having

been made with chain grate stokers. He had no wish, he said, to advertise anyone's goods, but in America he had seen steam meters made by the General Electric Co., of America, and by the B. T.-H. Co. in this country. One of these meters was fixed on a boiler tested recently at Glasgow, and the indications were so satisfactory when compared with the measured water in the tanks that they were proposing to equip each boiler with a steam meter, the same as an ammeter on a generator. The trouble and expense in large cities of keeping banked boilers to meet sudden darkness was a very serious one. In Glasgow it cost £5,000 a year. Mr. Fedden mentioned 15s. per ton of coal stored as being the cost of the coal handling plant. He (Mr. Lackie) had recently been looking into this question, and he had quotations which led him to think that stacking at the height at which they could do with Scotch coal, 7s. 6d. per ton gave an ample margin. The boiler house was just as important as the turbine room, and he was looking forward to seeing skilled and trained engineers in charge in the boiler house with a minimum of unskilled labour.

Mr. J. W. Beauchamp (Chief Electrical Engineer, West Ham), said he would like to enlarge upon the question of the ash plant, which was very important. In most cities there was no market for ashes, and it was necessary to obtain a tip, or to have them taken away. In London everybody paid a considerable sum. In some places as much as 2s. 6d. per ton was charged for barging the ashes to the lower reaches of the river. With regard to the cost of getting rid of ashes or putting them on to a tip, the total cost consisted of two items. If the ashes were sold at the door, so to speak, the cost varied directly with the tonnage, but if one bought land and dealt with them by means of machinery, the cost consisted of two items, one a fixed charge on the capital, and the other a small running charge, and the consequence was that in the latter case the cost of ash removal dropped very much as the quantity increased. This was a very important point, and, in the case of a big station, it encouraged one to deal with the matter in this way. He had a suction ash plant which had not been working for a sufficient length of time to obtain any precise costs, but, as far as he could see, they were going to be of the following order, and the figures might be somewhat interesting. The capital charges for the removal of 10,000 tons of ashes per annum from the ash tunnel to the slip, where they were transported by barge or cart, would come out to 7d. per ton, and the electrical energy 2d. That 7d., however, would become 3½d. if the quantity of ashes were doubled, as the plant had an

immense capacity for future development. There were not many suction ash plants in use yet. He had had one running for eight or nine months, and, so far as he could see, it was quite the most practicable way of removing the ashes. There was more than one maker, and there were two or three methods of dealing with the question. He used the pattern with a Roots exhauster, and no difficulty had been found with regard to repairs or erosion of pipes except at bends, but here it was easy to replace them, and the cost of replacing was very small indeed. The only difficulty found so far was with regard to the emission of dust, which depended upon the quality of coal used. This difficulty, however, was being dealt with by the makers, who were putting in a separator. It might also be dealt with by the use of wet screens, as used for cleaning the air of buildings. It was a difficulty which must be cured, because it really was a nuisance. The dust did not occur in the ash tunnel, the conditions in which were very much better than they were before, but it occurred when the air was blown out from the exhauster. He thought it was misleading to call it a suction ash plant, because, as a matter of fact, the long pipes into which the ashes were put were open at the far end, and the ashes were really conveyed along it by wind in the pipe and not by the ordinarily understood action of vacuum. Hitherto the difficulty had been to deal with surplus wind, and he understood one firm was erecting a return pipe from the exhauster, back to the hoppers where the ashes enter the main conveyor pipe, thus getting over the difficulty which exists at present in dealing with surplus air drawn in at each opening where the ash enters, causing some of the air to circulate round the plant continuously. That reduced the load on the blower motor and got rid of the dust difficulty to a very considerable extent. Where the clinker was hard a crusher was provided. Personally he had not found it necessary to use this. With regard to the general arrangement of boilers, both the author and Mr. Lackie had made reference to the erection of the economisers above the boilers. That was being done a great deal, and it lent itself very well to the arrangement of the boiler house and a saving in floor space, but there were one or two minor disadvantages, although not sufficient to affect a big station. For instance, with the economisers above the boilers, it was difficult to keep them full of water when the boiler was standing. There was a tendency for the level to drop and the upper part of the economiser to become full of air, therefore there was a delay when starting the feed pumps before water appeared in the boiler. Moreover, it seemed reasonable to anticipate that

corrosion would take place in the economiser at the air and water level, and it would probably be found necessary to make special arrangements to keep the economiser plumb full of water when the boilers were standing. Mr. Fedden's remarks as to stacking coal were very interesting, and his figure of £1 per ton for reinforced concrete bunkers had been found to be about the figure at West Ham, but the author's method of passing gas through the coal to keep it from taking fire was new to him and very interesting. He believed the authorities were divided as to whether coal stacks should be ventilated or tightly sealed. There were some interesting remarks on this subject in a recent number of the *Journal of Gas Lighting*, and he was under the impression that the author favoured sealing and not ventilating. With regard to the general design of power stations, there was one point which the author had not touched upon, and which had not received the attention it probably would in future designs for very large power stations, and that was the provision of air required for the consumption of fuel in the furnaces. This in large stations was of enormous volume, and whether natural or suction draught was used, this air was generally obtained from all sources, *i.e.*, through doors, windows and other openings, and during the winter weather, when there was a tendency to restrict openings to the outer air, very acute draughts might be produced. He believed some work had been done in the direction of leading the heated air from the engine room into the boiler for this purpose, but it did seem to be a scientific and natural method, tending to keep the engine-room cool and to provide the boiler furnaces with air which had already been raised to a fair temperature in the process of cooling generators. Unless attention was given to this point in the original design, it would often be found that basements, pipe openings, etc., would render any systematic method impossible. There was one other point, he said, certainly, worthy of attention where very large plants were being designed was the provision of adequate space and the proper arrangement of steam pipes. He did not so much refer to the lay out, levelling and draining of pipes (although the latter question became more important in large turbines than in small), but he referred to the provision of adequate space for the steam arrangements. There was no more important part of the plant, and it was a part which modern practice tended to put great reliance upon by the elimination of duplicate pipes, etc. It was so often found that all the chief items of plant were laid out with regard to their several needs, and finally the steam piping was left to wind its way about the station as best it could, dodging columns and climbing

stairs, after the manner of flexible cable. So important was the main header and the various mains, branches and joints, in connection with it, that it appeared to him in the case of a very large station one would be justified in providing it with a chamber running lengthways between the engine-room and boiler house. In this it would be properly accommodated. There would be ample room to work, and the valves could be kept clean and free from dust. If the chamber were enclosed it would act as a supplementary lagging of very considerable value. Furthermore, there would be an added protection in the event of any serious explosion in the boiler house. Electrical engineers had already been forced by experience to remodel their designs of switchgear many times, and to-day the switchgear and busbars in the generating station represented a considerable proportion of the total expenditure, and were never stinted in regard to space. He thought a somewhat similar generous consideration for all the principal pipe runs would be justified.

Mr. C. H. Wordingham (Admiralty) referring to the use of special trucks at Sheffield, said he was surprised that more use had not been made of the tippler ; in this arrangement the truck was clamped on to a platform which could be revolved about a horizontal axis, so allowing the whole of the coal to fall out of the truck without any hand labour. He was putting in an arrangement of that kind for a central station for which he was responsible, and believed it would give excellent results. It got over the difficulty of having special trucks and avoided the danger of damaging the railway companies' rolling stock. Mr. Fedden used a mixture of steam and electrically-driven boiler feed pumps, and it would be interesting to know upon what grounds he used both types. With regard to gas fired boilers, his remarks upon this might not be very popular. He supposed they were all entitled to dreams, and his dream was that eventually it would be found that there was such a community of interests between gas and electric supply, that the two would merge into one. That might not be yet, but it would come. There was obviously, in view of the large generating units now employed, an impossibility with our present knowledge of using large gas engines, and it might therefore well be urged against such a combined arrangement, that one serious objection was that we could not use large generating units. He thought, however, that the position might be altered and altered materially by the new system of combustion known as surface combustion, in which, instead of applying the gas to the engine, it was applied

to the boiler. Thus electrical engineers would be able to go on using their highly efficient steam turbines and would not have to make any radical alteration in the generation of electrical energy. It would assist greatly in this particular problem that had been called attention to in the paper, namely, the difficulty of getting the boiler house to be commensurate as regards the units with the generating units. In other words, surface combustion would enable them to use boilers of much greater steam raising capacity in a given space, and so enable them to get steam raising plant much more nearly of the same size as the steam turbine generating units.

Mr. W. C. P. Tapper (Chief Electrical Engineer, Stepney) congratulated the author on the very ingenious way in which he had turned what appeared to many an unsuitable site into a most desirable one. The author was fortunate in having a valley close by in which he could put his ashes, but in the part of London which he represented and which contained a population of nearly 300,000 within an area of about two square miles, it would be rather a difficulty to find a valley into which to put his ashes. He would like to know whether the figure of £10 per kw. in the paper, included plant and machinery and also buildings and land. It seemed such a remarkable figure that he could hardly think it did. With regard to the general arrangement of the boiler house, he was not at all sure that it was necessary to arrange the boilers at right angles to the engine room in order to get the necessary capacity. In Stepney he had found it possible to arrange the boilers parallel with the engine room for turbines up to 5,000 kws. At Stepney also he had put a steam feed heater into the hot well, and discharged the exhaust steam from the reciprocating pumps through the heater, thus retaining all the heat and discharging the oily condensed water into the drain. He was now putting in a turbine-driven rotary feed pump, and the whole of the exhaust from this would be turned direct into the hot well. As to induced draught, he was the first in this country to install the Prat system, having put in four chimneys dealing with eight boilers. In that case the chimneys worked on what was called the cold blast system, and they had worked entirely satisfactorily. In the extensions at Stepney he was putting in the later type of Prat chimney with the in-circuit system, *i.e.*, a system in which the fan draws a certain proportion of the boiler gases and passes them back under pressure into the chimney. The general arrangement would be a boiler with a travelling grate stoker with forced draught under the stoker and induced draught

above it, thus giving a balanced draught on the fire, each boiler complete with its own chimney. A matter which had already been mentioned was the question of the more economical use of coal by the recovery of by-products, and the use of gas for steam generating purposes. He would like to suggest that electrical engineers were not the proper people to take up the manufacture of gas. As a body they could not claim to know much about gas production, although no doubt some of their members knew something about it. The gas people had spent the capital and had the necessary experience. Therefore, in the long run he thought it would be found better to make terms with the gas companies to buy gas from them and use it in boilers. This, incidentally, would do away with the two most difficult features of the boiler house, namely the coal handling and ash handling plant.

Mr. Yorath Lewis (British Niclausse Boiler Co.) said that by the system of boilers such as had recently been installed at Southend, he claimed that it was possible to evaporate anything from 150 to 200 lbs. per square foot of ground space occupied. Mr. Fedden had set out in the paper what he considered to be the best combinations of plant available in this country to get the best overall efficiency and least maintenance cost. The second combination was indicated as likely to have the greater future presumably because of its overload capacity. There were many features of this equipment which he would like to discuss in detail, but would only notice in passing the draught pressure of 3·3 inches required for working at normal load, and that to provide this, both induced and forced draught plants were required aggregating 85 h.p. It would be of general interest if the author would supplement the data given by the table showing the thermal efficiencies independently determined on the lines prescribed by the Institution of Civil Engineers, and the power consumption for stokers, economisers and fans at both normal and overload ratings in that connection. He would be quite prepared any time to submit full details of any test performances made on "Britnic" equipments. He submitted that a superior combination could be presented of Britnic specialities throughout in units up to 60,000 or 70,000 lbs. of steam per hour as follows :—

(1) *Water Tube Boiler,* evaporating at normal load about 6·75 lbs. and at, say, 40 per cent. overload 9·5 lbs, per square foot of heating surface.

(2) *Superheater*, located immediately above the nest of boiler tubes and giving a steam temperature of say 650° F.

(3) *Steel Tube Economizer*, located immediately above the superheater and discharging gases to chimney at about 300° F.

(4) *Low Pressure Forced Draft Mechanical Stoker*, of liberal grate area, capable of ready adjustment to burn any class of coal from the richest to the poorest grade, absolutely without smoke and with the least possible amount of excess air, and at any rate of combustion between say ¾ load and 40 per cent. overload, without distress of any part.

(5) *Low Pressure Forced Draft Fan* in basement under firing floor to give a maximum of only about ½ inch air pressure in the stoker ashpit, and therefore requiring but relatively little power.

(6) *Plain Iron Chimney*, common to two boilers, of sufficient height to give only about ¾-inch draft for normal load, but fitted with an induced draft fan to give up to, say, 1¼ inch draft for overloads.

(7) *Ash Handling Arrangements*, comprising closed ashpit compartments automatically separating, storing and delivering green fuel riddlings, fine ash riddlings, and clinkers, in small size to special discharging apparatus.

Such an equipment was now within their reach, and he suggested that with it power station engineers could make great advances over anything that had yet been done in this country.

Mr. G. D. Seaton (Richardsons, Westgarth & Co.) referred to the question of guarantees of output of electrical machinery. Those, he said, who within the last year had been calling for tenders for steam turbines knew they had been offered some exceedingly fine steam consumptions, and at the last Annual Convention, he had the opportunity of pointing out how these very fine steam consumptions were obtained when they were foolish enough to give makers the opportunity. His remarks caused great discontent in certain quarters, as he had every intention that they should. He was now able to tell them one little sequel of last year's Convention. Some time ago he lost a substantial order for turbine plant owing to competitors guaranteeing a lb. per kw. more than he did. It was very soon found out in the boiler house that something was wrong, and this

something happened just at the time of last year's Convention. A member of the committee of the particular town listened to his remarks, and told his chairman and engineer what had been said, and added, " I have reason to think there is something in what the old beggar said," or words to that effect. The result was that a very severe test was put upon that plant. Was it better than what he had offered? " No, it was a jolly sight worse." Many engineers objected to calling in an independent man because they thought it was *infra dig*, but he would like to put it to the chairman and conveners that it was their duty to see that these plants were properly tested, and just think what an advantage it would be to a chairman supposing he caught a contractor bending. He would be able to go to his constituents and say that he had been able to do something. He had seen some of these steam consumption guarantees and knew what they meant.

Mr. A. Atkinson (Clarke, Chapman & Co., Ltd.) said Mr. Fedden in dealing with the boiler had done so very fairly, and it was open for the makers of the type of the few mentioned to explain their individual features which might be considered from an engineer's point of view to claim special attention.

It might be accepted that the horizontal straight tubes, whether fire or water tube, had no competitor, the vertically inclined straight tube boiler, however, had. This type of boiler appeared to be better suited to high efficiency, high forcing, with lower cost of maintenance than those of the horizontal type, and it might also be taken as more reliable. These advantages were being recognised by engineers to-day, and the question of bent tubes or straight, entered largely into his final decision.

It is claimed that the straight tube posessses advantages owing to their ease of access for cleaning and inspection, or renewal, for in the Woodeson type boiler, the tubes being all the same length, there is no undue straining of the drums. In this connection it is well to bear in mind that the expansion of tubes is governed by the temperature of the water inside the boiler, and not the temperature prevailing at the fire side.

It was a source of pride, which Mr. Fedden evidently felt, that engineers in the Old Country might justly claim to be leading the way in boilers as in other branches of engineering, probably more so, as they did not hear of boilers being imported.

The Woodeson boiler alone had supplanted some of the best Continental makes on the Continent, and when it was taken into account that these boilers had to pay import duty, it was clear proof that there were important points of excellence in the British straight vertical tube type of boiler.

Mr. Fedden had referred to the brickwork being very hot at the time of high rated combustion. This brick question was an important one, but a good brand of fire brick and a little care in their laying would meet the case.

We know of good results being obtained and maintained with underfeed stokers, using the best Welsh coal only, and we had observed no troubles, nor heard of any, and this plant had been in operation seven years.

Mr. Fedden had shown throughout his paper that the whole plant had received careful thought, and believe, with the full knowledge that a water tube boiler was a scientific instrument, he treated it accordingly.

The result would without a doubt prove satisfactory.

Mr. R. U. Bailey (Resident Engineer, Summer Lane, Birmingham). Mr. Fedden had rightly emphasised the great importance attached to feed water heating, but he noticed that at the Neepsend Station there was a total of eight live steam feed water heaters which raised the temperature of the feed water to 130° F., and apparently the exhaust steam from the feed pumps was only used to augment this. He did not know to what extent Mr. Fedden employed steam for running auxiliary plant, but the utilisation of the exhaust steam from such plant was, in his opinion, the most economical from two points of view, and he did not think, speaking generally, that steam auxiliaries were employed to the extent they deserved. In the first case, the chief consideration of a station engineer was " continuity of supply," and he did not think that the employment of a number of motor-driven auxiliaries tended to lessen the chances of immunity from shut-down. The adoption of steam for auxiliaries applied, of course, chiefly to the driving of main circulating pumps, air pumps, fans and other principal auxiliaries. In the event of an interruption to the supply, the motor-driven auxiliaries at once failed, and this, of course, greatly complicated the restoration of supply, and in many cases endangered the

plant, and in any case considerably increased the period in which the station had to get under way again (this being a very important matter where large penalites exist for interruption to the supply). In the second case, the small steam plant was less liable to break-down than motors where continuous running was necessary, and the employment of exhaust steam for feed heating purposes gave a very high economic result as the latent heat of the steam returned to the boilers. Mr. Fedden had given some figures relating to boiler duty. It was stated that when burning 25 lbs. of rough engine slack per square foot of grate area, 5·25 lbs. of water would be evaporated per square foot of heating surface. This amount of coal per square foot of grate area was exceedingly low when obtaining such high evaporation. In general practice he thought 32 lbs. per square foot was more likely to be obtained when working a water-tube boiler at its rated normal capacity. The figure of 5·25 lbs. of water evaporated per square foot of heating surface was exceptionally high as, in applying this duty to a standard 24,000 lbs. per hour Babcock boiler for comparative purposes, the duty would be 32,455 lbs. per hour from and at 212° F., which was 35·5 per cent. over duty. He therefore did not think that these figures were consistent with conditions obtained in common practice. A further set of figures were given relating to a duty obtained with the underfeed stoker, and it was intensely interesting to find that the boiler duty could be increased 65 per cent. above normal. It was very unfortunate that Mr. Fedden did not give fuller particulars of this performance, as it was undoubtedly always desirable, to obtain as far as possible on these tests, figures showing the economic results. He had not stated the thermal value of the fuel used nor the lbs. of water evaporated per lb. of coal, consequently they were unable to form any idea as to the thermal efficiency of the boiler working under these conditions. With reference to the remarks on stokers, Mr. Fedden enumerated the difficulties which existed with chain grate stokers, and undoubtedly when burning a fine slack, the handling of the riddlings made was a matter which had to be taken seriously into consideration, as this amount was, he thought, between 3 and 4 per cent. of the total coal passed over the stoker. These riddlings had, of course, a very much reduced calorific value as compared with the main fuel, due to the volatile matter being very small indeed—this value being previously extracted by the temperature to which the coal had been subjected. The riddlings however, had a high carbon value. The general practice was, he believed, to throw these riddlings periodically back again into the hoppers, but

this had the effect of spoiling the fires and upsetting uniform combustion. At Summer Lane Station two underfeed stokers were employed almost entirely burning these riddlings and it was found that this method was highly economical. It would, of course, be impossible to use a chain grate stoker entirely for this class of fuel, as having practically no volatile value there would be little or no flame, consequently the temperature of the arches would be below that necessary for igniting the fuel. Mr. Fedden touched upon the all-important question of coal storage, and every day the question of carrying a large coal reserve was becoming more important. Mr. Fedden also drew attention to the fact that screened nuts was the class of fuel which could be stored in comparative safety, but he thought Mr. Fedden had omitted to state the most important point of all in this connection, viz., that in the satisfactory storage of coal there must be entire absence of sulphur. It was undoubtedly the presence of sulphur in coal which was at the root of the evil of spontaneous combustion, the sulphur, which was usually present in the form of iron pirites, readily disintegrated and thereby caused heat to be generated. If coals which were free from sulphur were stacked, he thought that they could be treated with a certain amount of latitude. It might interest members to know that at Birmingham they were at present carrying a stock of 10,000 tons, the largest heap being 4,000 tons. This coal stock was made up of 3-inch nuts at the base, and graded through the various sizes of nuts to shallow screenings at the top. The depth of the stack was 12 feet. The object of this grading was to allow any local heat which might be generated, to be readily dispersed through the interstices of the coal. The chance of firing was, of course, greater at the base due to the weight of the coal above. A smaller heap made in this way containing 1,500 tons, had been down for about three years, and they had up to the present been unable to detect any appreciable rise in temperature above that of the atmosphere. They also had a smaller stack of 700 tons which had been standing for about six years, the heap consisting entirely of nutty screenings, and to-day practically showed as high a calorific value as when put down, the crust only being weathered. This latter stack was put down at the same time as other stacks of coal drawn from other collieries which readily gave trouble owing to spontaneous combustion, and they had since found by analyses that the coal standing to-day was the only coal free from sulphur, and it was on this finding that they had ventured to put down stocks of the size and depth he had just described. He noticed

that Mr. Fedden had purchased his coal to a rigid specification and that any coal which was found to be at all below the calorific value specified, had its price reduced proportionately. This latter point he did not think at all satisfactory, as coal people were apt to take advantage of this and dump upon one, coal for which they could not find a market and which was cheap at any price to be rid of. It was unnecessary to draw attention to what this meant in the way of interfering with the estimated running of the station. The cost sheet given in detail did not appear to give nearly enough particulars with regard to the coal, although the coal cost per unit was shown this did not show from week to week what any fluctuation there might be, was due to, as the market price of the coal burnt might vary considerably, therefore no provision was made for showing fluctuations due to the market, and fluctuations due to economic control. He thought that it was desirable to divide these two items and at the same time, to show exactly the conversion of coal into kw.hour, this was readily done in a station where a chemist was employed in taking the calorific values of the fuels delivered. It was then possible to show the average value in B.Th.U's of the coal for any period either weekly or monthly, and with this figure the B.Th.U.'s per kw. hour could readily be obtained, provided, of course, that accurate records were kept of the coal consumption. This B.Th.U. value immediately showed whatever fluctuation occurred in the economic working of the station plant, and this figure could be further expressed in the way of a " percentage thermal efficiency of the station." This would be found to be a long way below the 25 per cent. which Dr. Ferranti had spoken about on the previous evening. In conclusion Mr. Fedden forecasted the date when superheated steam would be generated to such a temperature that " a dull red gas would be passed through the pipes and valves "—he presumed that Mr. Fedden meant to imply that the temperature of the steam would be such that the steam pipes would take on this colour. If this was so the temperature so obtained was about 1,000° F., and although he was not quite sure of it, he thought that at this high temperature the steam would be decomposed. The oxidation of the metals would immediately occur and free hydrogen would be liberated. This, however, was a physical proposition which he thought was beyond most of them to-day.

Mr. W. R. Wood (Underfeed Stoker Co.) gave the results of some tests in which the evaporation was $8\frac{3}{4}$ lbs. per square foot of heating surface, the escaping gas in the boiler had a

temperature of 530°, and the escaping gas in the economisers had a temperature of 310°, whilst the efficiency was approximately 85 per cent. From this he maintained it could be argued that high rates of combustion under proper conditions did not reduce the efficiency of a boiler plant. Mr. Lackie had pointed out that with four boilers working at 30 lbs. per square foot the efficiency was lower than with five boilers working at 25 lbs. Mr. Lackie had, however, introduced another factor, viz., the increased heating surface, and he would like to know whether Mr. Lackie attributed the falling off in efficiency at higher rates of combustion to imperfect combustion, or to the additional heating surface, and whether the heating surface of the boilers which were being used was evaporating anything like the quantity of water per square foot of heating surface as the boilers at Sheffield.

Mr. J. K. Brydges (Chief Electrical Engineer, Eastbourne) said he noticed Mr. Fedden, with reference to his live steam heaters increased the temperature from 85 to 135°, and also put the exhaust from the feed pumps into the hot well. He would suggest that the exhaust contained sufficient heat to heat this water in the feed well up to a safe temperature to be put into the economisers so that economiser tubes would not be damaged. This would give as high a heat in the feed water as could be obtained in any other way, and there would be no necessity for the live steam feed heaters. Mr. Fedden had not expressed very definite views upon mechanical stokers one way or the other. The chain grate stoker was installed at Sheffield, but there was the moving grate stoker which was not exactly a chain grate because the surface which carried the fuel consisted of a chain of large flat slabs connected together, and the particular point about this stoker, he believed, was that it was the only moving grate stoker which could be operated with forced draught. The other forced draught stoker available, viz., the underfeed, must have a fan, and he could not understand why it was customary to put cold air into the grate, when he believed there was at hand an apparatus for pre-heating the air before it got into the boilers. If it were necessary to raise the temperature of the air after it got into the boilers for combustion, why not raise it before. It cost nothing, as this apparatus had merely to be put into the flue, and really they were getting something for nothing, with the exception of the capital expenditure, which was not large. He, like several other engineers, was contemplating putting down more boilers, and was anxious

to get one which was absolutely up-to-date. He believed these pre-heaters had been used in some places and he would like to hear the experiences with them, and what they saved in £ s. d. At present he had only a statement from the manufacturers, but he believed Mr. Bowden of Poplar had one, and he was sorry he was not present at the meeting. It had been suggested that the pre-heating of the air caused excessive burning of the grate bars on account of there being less cooling effect as compared with unheated air, and that it also necessarily means there must be a closed ash pit. He was rather surprised that Mr. Fedden had not referred to air heating in his summary of the most economical types of plant. Similarly he would like to have information with regard to induced draught plant, and whether the Prat system or the forced draught or any other type of cold draught was the best. With regard to coal storage it might be interesting to state that he found it absolutely impossible to store slack coal in heaps of more than about 8 feet deep, although his bunkers were 21 feet deep. He now used pea coal, and oddly enough, although it contained sulphur, in spite of what Mr. Bailey had said, he could safely stock this coal 18 feet deep. He had fitted tubes through which he could drop thermometers, and had not found the rise of temperature to be more than 10 to 12 degrees. With regard to evaporation per square foot of heating surface, he agreed with the previous speaker that 25 lbs. per square foot was plenty. A higher rate might do with a vertical tube boiler, but he did not think the same evaporation per square foot of heating surface could be got out of a B. & W. as out of a vertical tube boiler. It might be obtained, but he did not think it safe, and there would be trouble with the hogging of tubes at such a high duty. With regard to economy in boiler house repairs, the cleaning of horizontal tube boilers was a very serious matter indeed, and very expensive, because nowadays when the inspector came round at the annual inspection, he wanted every tube cap taken off. That was an enormous job with a land type of boiler, and with a marine boiler a still larger job, but with a vertical tube boiler it was possible to get at all the tubes with very little trouble indeed, and the time required for cleaning was also less with the latter.

Mr. F. Ayton (Chief Electrical Engineer, Ipswich) said that several speakers had touched upon the impossibility of a union in the future between the gas and electrical interests, but he was firmly of the belief that something of the sort might come about. The more active they were in developing the use of electricity

in every direction, and so displacing gas, the sooner would the gas companies be ready to sell gas at a low price to the electric supply people. He would like to know if any members of the Association had had experience in getting rid of ashes by means of the water pipe system, similar to that used for the ejection of ashes at sea. This might get rid of the difficulty of dust. With regard to draught, at Ipswich they had to rely on natural draught, and in connection with investigations he was continually making to find out in what direction he could improve the efficiency, he had kept the records of the variation of the draught with the wind in different directions, and the different strengths of wind. A curious result had been discovered by these investigations, viz., that when the wind was in the direction where it blew through the big double doors into the boiler house, he got a considerably higher draught with the same strength of wind, and this suggested to him that in designing the new boiler house it would be an advantage to arrange the openings on the four cardinal sides of the boiler house, so as to get the maximum effect by opening them on the side where the wind was blowing. He would like to know if that had been considered in any place. As to storing coal, he used Nottinghamshire slack, and stored in heaps not less than 12 feet deep, and had never had any trouble with firing. The coal, however, was not strong in sulphur contents. He would also like to ask for information as to the life of the links of chain grate stokers. He was always having trouble with these. He used the B. & W. type, in which each link had a small projection on the side to fit into the space between the adjacent two links, and had found these ends burned off in a very short time. It was a very big expense having to renew these links on a big chain grate, and if there were any means of getting over it he would be glad to hear of it. With regard to flues, when he was busy on the designs of the Ipswich station in Professor Kennedy's office, the original plans were for a station of a maximum capacity of 5,000 h.p. A deputation from the Ipswich Corporation then went to Sheffield and Sunderland, and in both places were told that the mistake had been made of designing the station on too small lines at the start. The result was that the deputation came back and reported to the committee dealing with the matter, who gave out instructions to immediately scrap the original plans, and design a station for a maximum of 15,000 h.p., building only a portion of this as a start. That was a big order, and it meant making boiler flues so large that in the initial stages of the undertaking one had a very big radiating surface and a large leakage surface in the flues,

and if he had to start *de novo* on the designs of such a station now he would be inclined to make the flues in sections and divide them into one or two horizontal divisions, and to work with an upper storey and a lower storey in each flue. This, it seemed to him, would result in less leakage surface during the times of light load. At Ipswich he was trying a bonus system for economy of coal in the boiler house. Many members of the Association had been good enough to supply him with information as to what they were doing in this direction, but not a great deal had been done as there were certain difficulties. He was trying a bonus system as an experiment, and the basis of it was that the coal costs were fixed for each quarter, and the bonus was given for any improvement on this. For the last quarter a figure of 0·31d. per unit generated had been fixed for the coal, the price being 16s. 4d. per ton. The system applied to the firemen, trimmers, drivers, switchboard attendants, and the shift engineers, because they all had a hand in this, and each of them could easily spoil the bonus for the others. On this question he suggested a standardisation or re-standardisation of the accounts of municipal electricity departments, in order to see what the coal costs really were in various power stations. At present it was impossible to see, looking at the records of the *Electrical Times*, whether one was doing better or worse than another, and he suggested that the coal should be given in B.Th.U. per unit generated, and also an item should be added giving the cost per 1,000 B.Th.U. delivered into the boiler house.

Mr. R. Hammond dealing with the concluding remarks of Mr. Ayton, said that it might be known to some of the members that he was the originator of the *Electrical Times* analyses, and was the original "Chesterfield Junior." Those analyses were made up from the official accounts, filed at the Board of Trade. It would be a splendid thing to carry out Mr. Ayton's suggestion, and instead of simply setting out the price of coal per unit to add the calorific value, but until the statutory form of accounts is altered so as to force every undertaker to include the calorific value in the returns, he was afraid that Mr. Ayton's dream would not come true. If, of course, central station engineers throughout the country were willing to supply the data, it could be done, but many of them were not. Reverting to the paper, the marvellous thing about Mr. Fedden was that he was able to handle a site which some people thought absolutely unsuitable, and which frightened most engineers when they saw it, especially those who had not the boldness of Mr. Fedden, and to

turn a most difficult site into a splendid one. Indeed, Mr. Fedden almost went to the extent of advising every engineer to look out for a duplicate site when he was building new works. One point upon which he was able to give information was with regard to the working of the Prat Ejector Draught system. He had recently spent four months in South Africa, and had examined the large new power station of the Transvaal Power Co., at Vereeniging, which would ultimately have a capacity of 80,000 kw. When he first saw it at a little distance he thought the works were not in operation, but subsequently found out that they were burning 1,000 tons of coal per day, though there was not the slightest amount of smoke to be seen coming out of the chimneys. That was his testimony of what was actually being done with the Prat system, and if Mr. Fedden's station worked with the same efficiency throughout he was not surprised that he had got the costs to so low a point as was seen by the paper.

Mr. S. Utting said he was very pleased to see that Mr. Fedden had come to the conclusion that 25 lbs. per square foot of grate area was a good figure. There were, however, times when that figure could not be upheld. Circumstances arose which made it necessary that no matter what the particular engineer's feelings on the matter might be, he could not afford to put down a plant to work with a normal rating of 25 lbs. per square foot, and, therefore, he must adopt higher rates of combustion, which meant more active draught. He was very pleased that Mr. Fedden, unlike many other engineers, had referred to the system as the "Prat," and not to an ejector or augmented draught system. He did not see why a system which was the result of nineteen or twenty years' practical working, should not be known by its name in just the same way as, for instance, the Corliss engine was known. If the matter were investigated, it would be found that the Prat system was the only one entitled to the name "induced." Mr. Fedden had given the results of some of his tests, and said that the outgoing gases to the chimney were below 300° F. There were frequently, in central stations in England, cases in which the gases were at 240° to 300° F., and there were several central stations on the Continent where they were getting even lower. To get the result quoted by Mr. Fedden with natural draught would need a chimney 400 or 450 feet high. Mr. Tapper was the first central station engineer in this country who had experience of the Prat system by which cold air was injected into the chimney in order to induce the flow of the

main current. He had spoken to many engineers, and they seemed to imagine that the Prat system consisted solely of an *évasé* chimney and cold air injection, but nine or ten years ago, Prat developed another means whereby he used the main flue gases in order to create this induction. Such a plant had actually been designed for Birmingham, and had been working for some time. Mr. Prat could tell them that if with his most efficient "out-of-circuit" system 100 units were required, then his "in-circuit" system would take 75 units; in other words, there was a 25 per cent. reduction in fan power. If it were dealing with cold air it was necessary to deal with the main products of combustion, representing 100 per cent. plus the cold air required for injection, which was no small amount, and consequently the apparatus must be bigger. There were not many of this new type of plant in this country that could be quoted, and, therefore, there were not many engineers who could give Mr. Fedden the practical information he asked for. Sheffield Corporation put the first one down, although Southampton Docks had one down almost immediately afterwards. At Sheffield it was in the Tramways Department. There the plant was working on two boilers, a similar arrangement to that now adopted by Mr. Fedden, the boilers being side by side, and having a 30,000 lbs. normal evaporation. From some test figures he had, it would be seen that the load corresponded to about 7 per cent. overload. The plant was burning 6,420 lbs. of coal per hour and there was only an induced draught fan, no forced draught, and the simple Prat "in-circuit," system, the h.p. on the fan being 21. The plant at Birmingham was tested three or four weeks ago, and the average of three tests worked out at 9,600 lbs. of coal per hour; the average draught was from 31 to 33 millimetres, and the h.p. was 35. That did not compare very unfavourably with Mr. Fedden's figures of 85 B.H.P., for what appears to correspond to a combustion of 9,600 lbs. per hour with the combined forced and induced draught, and which constituted an admirable arrangement where the rate of combustion must be for ordinary conditions something in the neighbourhood of 30 to 35 or even more lbs. per square foot of grate surface.

Alderman H. Gervis (Brighton) said he agreed with Mr. Fedden as to the employment of highly trained technical men, but it was the most difficult thing to do to convince a council—at least, it was so in the South of England; he did not know what prevailed in the Midlands or the North. In the South of England the democracy was most unwilling to pay for brains.

A great deal was heard as to the work that was done by the working men, and the production which was brought about by their work; but nothing was heard of the brains that made that production possible. Mr. Christie would bear him out when he said, as Chairman of the Brighton Lighting Committee, that he could go down to his committee with the lightest heart, and ask them to pass large sums for mechanical plants and apparatus, and, as a rule, the Council would pass the recommendation with, perhaps, three minutes' discussion, or probably none at all; but if he went to his Council to ask for a rise of salary of a few shillings for a highly scientific and skilful employee it meant two hours of acrimonious discussion. As a rule, in a council the big employer of labour was willing to pay large salaries, because he knew quite well in his own business the value of paying for brains. The professional man would also be found on the side of large salaries, but the small business man, and the working man would himself—there were exceptions, of course—fight to the death in order to avoid any rise of salary, and in order, when getting any new employees, to pay the very lowest salary possible.

Dr. S. Z. de Ferranti speaking first with regard to air heating for boiler fires, said that theoretically it was perfectly right to heat the air for combustion under the boiler, but in practice little satisfaction had been obtained from this process. He had kept in touch with this matter for a fair number of years, both in seeing what others had done and in experimenting himself, and the real trouble was that the apparatus, which in itself was very simple, was not at all efficient. In the first place, the plant was invariably put in too small, and the result was that instead of the air being properly heated up to a fair equivalent of the temperature of the outgoing gases, a very poor result was obtained. That was the first part of the practical failure. He knew of particular installations, not so much in electricity works, but in factories in this country, where the system had been used, but no special results had been got from it, and no further installations had been put in. An investigation of the causes showed that with only a moderate efficiency from the plant there had been very great trouble with fire bars, which with hand stoking had stood fairly but with various forms of mechanical stokers had given nothing but trouble. A fire grate depends for its existence upon the lowering of the temperature of the bars by the incoming cold air, which was regenerated in the process, but when they started with moderately

hot air in the bars instead of cold air, the temperature of the surface of the bars was not kept to a sufficiently low degree to enable the bars to stand. Slagging appeared to be the worst trouble, and the surface of the bar was eaten away. Consequently they came to this interesting state of affairs that either the apparatus did not work to the extent it was anticipated, or if it did the other part of the apparatus, viz., the grate, failed. It must not, however, be imagined that that would always occur, or that he wished to put engineers in doubt as to the development of this apparatus. All he warned them to do was to take nothing for granted, and to be as sure as they could that they were going to make a real saving, and that the money spent would be well spent. The other point which he wished to speak upon was with regard to gas. They had all in view what he might term a peace between the gas and electrical industries. That was an ideal which he had had in mind in the past a good deal. If by-product recovery on a paying scale was to be adopted for the generation of electricity, the processes at present in use, and the present practice of making gas for lighting and heating would have to be entirely revolutionised. There were essential costs both in capital and in the working of these processes which put them entirely out of concord, and for that reason he saw no possibility of bringing the two industries together in the mutual process of supplying the public with one product for all purposes, viz. electricity. The process of gas manufacture as now carried on was so different from what would have to be the case if it was to hold its own on merit, that he was afraid the ideal was a long way off.

Mr. W. M. Selvey (Sheffield) said that speaking as an outsider he was a little surprised that there had been no real note of appreciation of the paper. Everybody had said it was a fine paper, but it struck him as being typical of the modest man who had done work and not a man who was simply writing about it. He was very strongly impressed when he went over Neepsend the other day with what had been done there with the site. It was no fair criticism to say that in any case it was an unsuitable site at the time it was chosen. The wildest dreamer could not have predicted the increase in load which has been obtained in Sheffield, which was one of the worst districts for pioneer work in the electrical world. It was the very home of the small man; it stood for individualism, and was teeming with Waste Heat, yet Mr. Fedden could come in without selling energy at a loss and develop his load in such a way as had been shown in the paper.

That was nothing short of genius, and the work done there ought to have met with a great deal more appreciation among the members. He did not think the commercial point of view had been introduced into this discussion at all. So far as the question of buying was concerned, nobody had touched upon the question of boiler house design from the point of view of the raw material they were buying for the purpose of turning out their finished product. The question of buying coal was one which would come very largely before power station engineers in the future. At present coal buying was left largely to the coal broker and it had always been a grievance of the engineer that he had no voice in buying coal. The reason, however, was entirely the fault of the engineer himself. The speaker was connected with Metallurgy and in this field some of the greatest business in the world had been built up in dealing with ores containing 3 to 5 per cent. of copper and $1\frac{1}{2}$ to 2 ounces of gold per ton. In that line there had been great difficulties in sampling which had resulted in an advanced practice in automatic sampling. With the exception of the Sturtevant sampler, he believed nobody had tackled the question of automatic sampling, as applied to coal. The real reason why engineers had no certain voice in this was that some such system was not standardised for coal. Another question was that this raw material coal was turned into another raw material steam. They had been discussing the apparatus for turning the one into the other, but he had not heard a single remark about the kind of raw material which was being made. Mr. Fedden's paper had left the matter open to everybody for discussion and only one speaker had mentioned the question of red hot steam. Nobody had taken up the question of the relation of coal to the furnace which it was burned in, and he would like to make a few short remarks about that. Mr. Fedden had been speaking about high rates of burning. Those who wanted to know anything about the difficulties of burning coal at a high rate should go to the people who burned it. At present he did not think power station engineers burned coal in this sense. The people who really burned coal were the Navy people and the Locomotive people. If they wanted to find out how to improve their rates of steaming they should consider the experience of people who had had a very much harder problem than central station engineers. If they wished to find out how to get up the evaporation per square foot of floor surface in their boiler house they should sit at the the feet of those men who had solved one of the most difficult problems in engineering to-day. It would be necessary more

and more in the future to keep boilers at right angles to the engine room, and to make these boilers even bigger. It would be necessary to put the economiser on top of the boiler and make it fill the whole of the available space that there was on the ground plan of the boiler. Even with this they would have serious difficulties in keeping the boiler house alongside 20,000 kw. units. The question of the boiler house in this respect was entirely one of the stoker. Think what they had done. In the engine-room they had an alternator which would give quickly from 100 per cent. overload to quite a light load and give a satisfactory service all the time. They had turbines which could be governed to any degree of nicety for any practical requirements in the variation of speed or output, but what had they done in the boiler house? The size and flexibility of boilers had not materially increased, in other words they had rested by the way and now that it was time to move it was found necessary to go to America for stokers. He did not think this was necessary, and although the Taylor stoker was quite good, it was only a passing phase. It was necessary to go to the rock bottom to see what was wanted. Two things were wanted; first, a perforated platform to support the coal, and secondly a means of driving this platform with ease and speed. Developments in this direction have already been made, and particularly in the direction of separating the function of the platform from the function of the driver, and this tended to make the arrangement flexible in the same way as the governor made a turbine flexible. Finally with regard to co-operating with gas making; this was a thing which they all had greatly in mind, but he would like to point out that the bulk of coal was carbon. That carbon as far as he could see would always have to be burned; therefore, what they were going to do was to introduce another link in the chain of raw materials. They were starting with coal which could be manufactured into coke. This was turned into steam and finally steam into electricity, so that before anything could be done in this direction, if it was ever going to be done, it would be necessary to help Gas people to get rid of their gas coke which was one of their present anxieties. When electrical engineers could assist the gas industry by using boilers in which gas coke could be used efficiently, then it would be time to think about whether they could do anything in conjunction.

A hearty vote of thanks to Mr. Fedden was proposed by the President, and was cordially responded to.

Mr. S. E. Fedden in his reply (*Communicated*) says he was exceedingly interested in Mr. Lackie's remarks with reference to his recent American tour. He entirely agrees with him that engineers in future should as far as possible make their boiler houses as good as their engine-rooms and other parts of the Station. Mr. Lackie mentions that until recently it had been his custom to put in boiler units of about 4,000 square feet of heating surface. The boilers installed at Neepsend for some years past have had a heating surface of 9,611 square feet, and the author can quite agree with Mr. Lackie that boilers of this size are just as easy and more economical to run than a large number of small boilers. He can also endorse his remarks that nothing but steel valves, pipes, etc., should be used with superheated steam, because not only are explosions likely to occur with split valves and pipes, but it is almost impossible to shut off a valve and make it steam tight—owing to the distortion of the body of the valve the seat is generally quite loose.

Mr. Lackie's remarks with regard to the saving during one year of £10,000 in his coal bill by employing scientific men and indicating instruments to check his general boiler-house efficiency, fully bears out the author's claim as set out in the last paragraph of his paper.

He agrees that bucket conveyors are not suitable for dealing with ashes, the wear and tear being far too great.

It seems to him that there is a greater chance of error if the suggestion that the cost of coal per kw. hour be stated as the number of British thermal units, because he has found that the results from the burning of two different kinds of coal, both showing the same calorific value, vary very considerably.

He will watch with great interest the results of the tests carried out on the new Taylor stoker which is being installed at Glasgow, with which Mr. Lackie hopes to obtain equal or better results than with the class E Underfeed stokers.

Mr. Beauchamp contributed some valuable remarks with regard to his experience with suction ash plant, and also regarding the design of Power Stations. Mr. Fedden intimated that on account of the excessive draughts he had already made special arrangements for the admission of air into the boiler house independent of the opening of the doors and windows.

Mr. Wordingham and other speakers referred to the special bottom-tipping trucks in use at Sheffield. These trucks are not at all special, as they are in general use in the trade in Yorkshire. The tippler suggested would be very expensive and would only be able to tip on one spot. It would be wholly unsuitable for the author's lay out at Neepsend, as he requires to tip over a large area where the railway lines are laid down.

Replying to Mr. Wordingham's inquiry as to why the author has mixed steam and electrically-driven boiler pumps, this has been done for experimental purposes; he has to use feed-water heaters in any case and put in the duplicate feed pump electrically driven to prove which is the more efficient in running.

Mr. Tapper seems to consider that the author's figure of £10 per kw. for the erection of the station, including cost of land, is too low. He has gone into the matter very carefully with his Accountant, and can assure Mr. Tapper that the figure stated is quite correct, and includes land, buildings, railway siding, water goit from the river, boiler plant, engine-room plant, capstans, lifts, and everything complete.

Mr. Lewis submitted that he could give a superior combination to evaporate 60,000 to 70,000 lbs. of steam per hour, and up to 9 lbs. per square foot of heating surface at 40 per cent. overload. Mr. Fedden suggests there is very little to choose between Mr. Lewis's figures and the figures the author has put forward.

Mr. R. W. Bailey contributed some most interesting and instructive remarks. He seemed to doubt the evaporation of 5·52 lbs. of water per square foot of heating surface. That may appear to be high with the class of boilers he uses, but it is by no means a high figure with vertical tube boilers, and this figure is quite consistent with our ordinary practice.

He regrets that the author does not give fuller particulars of the performance of the boiler when it was working at 65 per cent. above normal rating. Mr. Wood, of the Underfeed Stoker Company, who carried out this test, gave the figures during his contribution to the discussion, so that there is no need for the author to add anything further on this point.

Mr. Bailey's remarks regarding the storage of coal are most interesting, as they are obtained from actual practice. It seems evident that the less sulphur present in the coal the greater safety there is in storing without chance of heating.

Mr. Brydges chiefly inquired for information with regard to the pre-heating of the air before it entered the boiler. Mr. Fedden has used the Ellis & Eaves induced draught arrangement for the last twelve to thirteen years, and has found it most satisfactory. The hot air, however, has only been used with Bennis compressed air stokers, in which the hot air is drawn from the back of the boiler and passed through the centre of the hollow bars along with the steam jet to induce suction. The only reason why he gave up the use of the Ellis & Eaves induced draught system was the lack of warm water in the back end tubes of the boiler; for that reason he changed over to economisers.

Mr. Ayton complains of the excessive wear of the links on the chain grate stokers. Mr. Fedden thinks every user of chain grate stokers experiences this trouble. If, however, he will adopt the thinner class of link which Messrs. Babcock & Wilcox are now making, Mr. Fedden is of opinion that he will get a good deal more air through his grate and consequently less burning of his links, besides being able to burn more coal per square foot with less riddlings of fine coal passing through.

The experience of Mr. Hammond, Mr. Tapper and Mr. Utting regarding the Prat system were very interesting, if not quite convincing. Mr. Fedden hopes, however, to go further into this matter in the future.

Mr. Selvey, in dealing with the purchase of the large amount of raw material with which Engineers have to deal further emphasises the author's point that the best economy is secured by engaging men with the best scientific knowledge on the subject.

Incorporated Municipal Electrical Association.

BIRMINGHAM CONVENTION, 1914.

THURSDAY, JUNE 18th.

MEETING AT STRATFORD-ON-AVON.

The Association met at the Memorial Lecture Room, Waterside, Stratford-on-Avon, and was welcomed by His Worship the Mayor, Councillor F. Winter, J.P.

The Mayor said it was with great pleasure that he offered a welcome to such a representative gathering as the Incorporated Municipal Electrical Association, which represented a department of municipal enterprise that had progressed with more rapidity than any other department of industrial science, probably because it had such an unrivalled opportunity for progress and extension. No visit to Warwickshire would be complete that did not include in its itinerary Stratford, the birthplace, the home, and the resting-place of the world's greatest poet. Unfortunately, the visit of the Association was to be of very short duration, but he hoped that what the members saw would develop in each one of them a desire for a more extended visit at some future time. To Shakespearean students, and no doubt there were many among the members of the Incorporated Municipal Electrical Association, the associations of Stratford-on-Avon would be of surpassing interest, although he was afraid there would not be time for them to inhale the true Shakespearean atmosphere.

The President thanked the Mayor in the name of the Association for his kind welcome.

The Standardization of Tariffs.

By J. HORACE BOWDEN (*Member*).

Chief Electrical Engineer of the Corporation of Poplar.

Policy.

BEFORE standardization of tariffs can be brought about, it is essential that the broad lines of policy to be adopted by Electricity Committees generally should be agreed upon.

The author will endeavour to lay before the Association his views upon Municipal Trading as applied to electricity supply, with the object of promoting a discussion thereon in which the lay members of the Association can take an active and distinctly valuable part, which should result in giving material assistance to the technical members in promoting a system of charging which, by its general adoption, would become standardized.

Unfortunately for the electrical industry, the object of primary importance in the minds of many local legislators is that an undertaking exists solely for the making of profits for the relief of rates.

Others again become imbued with the idea that the compulsory system of loans redemption means that at some

future date the local authority will have acquired an asset capable of producing large revenues for the public use, and therefore, by shortening the periods of redemption, the consummation of their ideal will be realized at the earliest possible date.

These measures must be eliminated from electricity politics before it is possible to bring about standardization of tariffs.

In the author's opinion the primary object of a Municipal supply of electricity is the universal use of energy for power, light and heat at the lowest possible cost to the consumer, compatible with efficient service.

The secondary object is the concentration of fuel combustion in a given area, and at that centre the obtaining of efficient combustion.

The question of relief of rates is a controversial one. It has been persistently urged that inasmuch as the general body of ratepayers is responsible for any loss that may occur through the operation of electricity supply in any given year, so that body has a just right to participate in any surplus that may accrue. The author contends that it should only be incumbent upon the undertaking to make good any contributions that may have been received from the rates, providing that all public services are rendered on an absolute cost basis.

If it is recognized in the policy of an undertaking that the supply is established for the benefit of all ratepayers, there is no logical reason for restricting the progress of the supply by imposing charges higher than are necessary to cover actual expenditure. The ultimate aim is to afford the supply to every user of power, light and heat in the area, and that aim can only be accomplished by supplying at the lowest possible rates. Apart from all considerations of hygiene, the dominating factor in the use of electricity is price.

Electricity, originally supplied as a luxury, is now rapidly becoming a necessity, and it must be admitted that public necessities ought to be supplied at the lowest possible cost.

If it were possible to so arrange tariffs as to produce an income exactly equivalent to expenditure, such tariffs, if conceived on equitable bases, would undoubtedly be ideal, but there are contingencies which prevent the consummation of the ideal, notably the fluctuations in the price of coal and maintenance of plant, buildings and mains.

It is practical to create a contingency fund in order to equalize these fluctuations over a period of years, but even if such a course were adopted, the prudent manager must always provide a sufficient margin to show a surplus at the end of the period, therefore, in a successfully managed undertaking there should always be a balance available for disposal outside the working of the undertaking.

This margin or surplus would, of course, vary with the output of the undertaking, and in a progressive concern the sum available should increase each year.

The ultimate disposal of this sum should be at the discretion of the local Council, but as the amount should be comparatively small, and of little effect in reduction of rates, the author submits, as being the most suitable practice to adopt, that a special fund be created from which the cost of special public improvements could be taken, which would be monumental of the benefit to the community of electricity undertakings apart from their legitimate sphere of public utility.

The question of acquisition of an asset producing revenue free from debt should be at once dismissed from the minds of all councillors so that the present capital restrictions may be readily removed.

The immediate future holds out the prospect of large sums being necessary for laying mains and providing meters and services.

All members of the Association have probably heard from time to time that "electricity is in its infancy." This stage has expired, and we now find that electricity has reached sturdy manhood, but, as far as cooking and heating are concerned, it may still be stated that electricity is in its infancy.

Recent developments in electrical cooking and heating appliances, however, tend to indicate that even this branch is passing from its infantile stage, and that in the immediate future we shall witness the passing of gas cooking and heating. No one can conceive of the enormous impetus that will be given to the electrical industry during the next few years if the management is untrammelled by false capital restrictions.

The author does not advocate the borrowing of money to supply cooking and heating appliances on hire; provision should be made out of revenue for any expenditure that may be necessary in this direction. Many consumers will no doubt purchase these outright, but provision should be made to supply a definite number each year for hiring out, particularly in working-class areas.

The Local Government Board now allows periods from twenty-five to fifteen years for the repayment of loans on account of mains, and the London County Council has fixed the maximum period at twenty-five years. Twelve and ten years are considered suitable periods for services and meters respectively.

Why these bodies, in their wisdom, should have fixed these arbitrary periods is beyond the conception of the author.

It has been stated that the Local Government Board is actuated by the desire to put a stop to or to modify the practice of contributing to the relief of rates, and that the London County Council is desirous of curtailing capital expenditure with a view to the acquisition of municipal undertakings at some future date on exceptional terms.

Both of these ends are reprehensible, and united action should be taken by Local Authorities to resist to the utmost the methods adopted for their attainment.

The law of continuity of supply renders it imperative that mains, services and meters shall always be kept in a perfect state of efficiency, and there does not appear to be any valid reason why the extreme limit allowed by law for repayment of the loans for these purposes should not be granted, namely, sixty years.

If it be assumed for the sake of illustration that the distribution side of an undertaking has been developed by private enterprise up to that point where every ratepayer in an area has become a consumer, during which period the whole system has been kept in a perfectly efficient state, the Local Authority would be expected to take over the concern at the value sunk therein. During the period of development the private capital would merely have borne the rate of interest and the cost of upkeep, but, immediately the transfer is made, an addition to the charges must be imposed, varying from 4 per cent. to 10 per cent. on the capital invested, for periods from ten to twenty-five years only, when the charges need bear only the cost of upkeep.

It appears to be unreasonable to tax the consumer of the period immediately following such transfer, and free the consumer ever afterwards.

Loans in perpetuity for these purposes and for land might very reasonably be advocated, excepting for the remote possibility that at some future date electricity supply

may be superseded by some as yet undiscovered power, but, in the author's opinion, this remote possibility would be amply guarded against by the extension of these loan periods to sixty years, or even one hundred years (without taking into account the residual value of the assets), and so prevent the penalization of one generation for the benefit of another.

Buildings and machinery are not governed by the same law as the means of distribution. It can never be anticipated that engineering science will stand still, and there must be a succession of replacements for many years to come. These replacements will undoubtedly be frequent until the whole load of an area has been acquired, and afterwards the law of depreciation will take effect, and so it may be assumed that complete acquisition can never be realized.

These are matters for consideration at the hands of electricity Committees which must be well defined before the responsible manager can attempt to evolve an equitable tariff. The present elastic ideas in regard to these matters are largely responsible for the uncertain methods by which charges for the supply of energy are brought into existence, and it behoves the lay members of this Association to endeavour to evolve order out of chaos, and assist the progress of this all-important industry.

The Tariff Ideal.

The author submits, without fear of contradiction, that any system by which a return to the undertaking could be made by each consumer of the exact cost entailed by the demand of each consumer, would be ideal.

Municipal trading does not admit of penalizing one consumer for the benefit of another, or one class for the benefit of another class. Such a principle is as fallacious as taxing one class of the community (consumers of energy)

for the benefit of another class (the general body of rate-payers) by exacting contributions to rates from electricity funds.

While it may be true that the laws of expediency govern private enterprise, it should never be lost sight of that Municipal enterprise is governed by the laws of equity.

No argument, however specious, will alter the fact that it is inequitable to supply to one class of consumer at a loss which is to be recouped from another class.

The future practice in electricity supply is undoubtedly that which will enable an authority to assess an annual charge for declared requirements, irrespective of the purpose to which power may be applied, or to the extent that such power may be used.

The present day practice renders it essential that a secondary charge must be made in order to restrict unlimited use of power for the sole reason that certain running costs are entailed in the production of electrical energy.

There is a possibility in the near future that these running costs will be entirely eliminated by the sale of by-products resulting from the gasification of coal, and the use of the gas and coke products for steaming purposes, or for gas turbines or other gas driven plant, and further revenue may be obtained from the sale of exhaust steam for heating, etc.

From the present day to the period when the practice forecasted may become practical, a secondary charge remains essential, and it is in the interests of all concerned in the supply to standardize such charge, and for this purpose the Association known as the " Point Fives " came into being.

The charge of 0·5d. per unit carries with it, in modern undertakings, a sufficient margin over and above running cost to allow for fluctuations in price of coal, and provision

against all contingencies such as breakdown of electrical machinery and failure of distributing and feeder cables.

Assuming that running costs will in the future be entirely eliminated, and no secondary charge necessary, any surplus income must be realized from the primary source, therefore it is absolutely essential at this juncture to construct the primary charge upon a scientific basis which will be applicable in the future as at present.

The practice which called the Point Five Association into being, is undoubtedly a mere stop-gap, but the opportunity should now be taken of using this means to obtain the ultimate end in establishing a system that can be applied universally to all classes of supply.

Some undertakers have considered it expedient to apply only the secondary charge for domestic purposes. Others, again, have considered it expedient to impose the primary charge on one class of supply only, viz.: lighting, and to apply the secondary charge to all other uses. It does not require great reasoning powers to foresee that a policy of this sort is of a transient nature.

The Norwich, or Rateable Value System.

It is the author's intention to refrain from criticizing existing systems of charging as much as possible, but as many undertakers, realizing that past methods have tended to unpopularize the use of electricity, have adopted the rateable value system for assessing a primary charge; but no more pernicious system has ever been introduced into electricity practice.

Its only attributes are those of expendiency and simplicity in its application to domestic property, which no doubt was the original intention of the introducer.

Apart from the insurmountable objection to this system raised by the fact that tenants in houses similarly assessed may make most divergent demands upon the resources of an undertaking, there are many serious obstacles to the attainment of permanent adoption.

Rateable value is generally dependent upon rent obtainable, and varies accordingly. Take the instance of property in a decadent area ; as the value of property decreases the demand for electricity would naturally increase from the fact that originally in the possession of one family, it degenerates into tenements of several families.

It is useless to advance the argument that the poorer tenants would not demand a supply, as the ultimate aim is to supersede all other sources of power, light and heat. In this case we have the instance of a falling revenue with an increased cost.

Another instance is that of a tenant obtaining possession of property at a reduced rental *because of installing electricity.* One of the strongest arguments in favour of the supply is that the necessity for internal decoration of house property is considerably lessened, and it is now quite practical for a tenant to make an agreement with a landlord not to require internal decorative work during a specified term of tenancy at a reduced rental, and incidentally a lower rateable value. Thus, on the rateable value system the introduction of the supply reacts against the financial welfare of the undertaking.

The assessment on dwellings at and under £20 per annum is generally much lower than the better class, due to compounding by the landlords, yet this class of tenant will make a greater demand in proportion to rateable value than the possessor of a residence with a number of rooms, landings and offices occasionally lighted.

Again, the working class is generally more prolific than the genteel class, and, having a greater number of mouths

to feed, cooking operations are carried out at more frequent and irregular hours of the day, thus raising the diversity factor for their class.

It has never been suggested that occupiers of property rented at £13 to £20 per annum with a rebate of 20 per cent. to 25 per cent. for compounding should be treated differently to the tenant of property rented over £20 per annum, bearing full assessment. This class of consumer does not appear to have been considered, yet this is a source of supply hardly yet tapped, and which is perhaps the most profitable class to the Gas Companies.

In the Poplar area there are 3,259 houses rated over £20 per annum, and the author estimates that an average use of energy could be made by each tenant of 3,000 units per annum under present conditions of supply, which would be materially increased if the secondary charge were to be eliminated. But there are 19,866 houses rated at and under £20 each, having a prospective use of 1,000 units per annum under present conditions. The field for exploitation in the first instance is only 10,000,000 units per annum, whereas in the second instance it is about double, therefore the working class of supply demands equal consideration with the genteel class.

But when the case of the shop-keeping class is considered, there does not appear to be any justification whatever for the system. Shop rent is chiefly dependent upon environment, and premises in a main and important thoroughfare may command double the rent of similar premises in a street of minor importance, whereas the latter may require greater illuminating power than the former in order to attract attention.

The assessment of licensed premises is generally considerably greater than other business premises making a similar demand for light.

Instances are constantly arising of change of proprietorship, and consequent change in demand for lighting, according to the nature of the businesses involved, without any change whatever in the rateable value of the property.

The application of the rateable value system to factories is perhaps more appropriate than to any other class of supply, and the rating officials would probably welcome an innovation whereby the h.p. installed would come directly under their notice, but it is doubtful if the consumer would duly appreciate a rise in rateable value consequent upon his increased demand for electrical power. It appears to be a curious fact that the only equitable application of the rateable value system would act as a deterrent to the adoption of electricity because, as a natural sequence to the installation of, say, an additional 100 h.p. motor, the Electricity Department would apply to the Rating Department to make an increased assessment on the property of that particular consumer.

The strongest advocates of this system would strenuously oppose the application to factory supply, and but few would attempt to apply it to business supply of any description.

But apart from the inherent impracticability of rateable value as the basis of fixing a charge for universal supply, there is the objection of handing over to another Department the onus of fixing the primary charge for electricity.

Those who have struggled in the past and succeeded in freeing themselves from the trammels of outside financial influence should now be extremely chary in handing over part of their duties to still another Department of Council control.

Granted that the forecast of the elimination of the secondary charge is realized, nothing but the assessment remains. The power of assessment having been voluntarily handed

over to another Department, it is only a natural sequence for that Department to undertake the collection of such charges, and the engineer becomes subservient to the dictates of the Finance and Rating Departments, and his province is one of attending to his machinery alone. Once the element of business is eradicated from electricity supply, the present high status of the profession will be considerably lowered.

The following is an extract from the *Times Engineering Supplement*, dated January 28th, 1914 :—

THE RATEABLE VALUE CHARGE.

> That it is almost farcically unjust is by no means a sufficient argument against the growing adoption of the "rateable value" method of charging for domestic electric service. The central station manager is not an officer of justice, but a business man charged with the duty of earning profit. At the recent meeting of the association known as the "Point Fives," Mr. Seabrook stated concisely the advantages of the method in its simplicity, and in its encouragement of heating, cooking, and other uses ; and to Mr. Seabrook the taxation of the mere lighting consumer so that the electric apparatus pioneers may do their cooking more cheaply brings no qualms of conscience. Still, it remains more conformable to business principles that the initial charge should be proportionate to the size of the installation, rather than to the rateable value, which is often greater for a small house in a fashionable street than for a larger house on the same mains in the suburban hinterland.

Needless to state the author thoroughly endorses the view taken by the editor as to the almost farcical unjustness of the system.

THE USE OF DIVERSITY FACTORS IN ASSESSING FIXED CHARGES.

The principal obstacle to standardization of tariffs is the fact that conditions of supply vary considerably in almost every area, and it has been urged that it is impossible to set forth any system that could be equally applicable to all undertakings.

But this argument can also be extended to each individual consumer, as no two consumers make exactly similar demands upon the undertaking.

It is this diversity in the use of energy that imposes upon supply authorities the necessity to adopt a form of assessment as the primary charge, and if it can be shown to be practicable to establish a tariff on an equitable basis applicable to the demands of any area, it is equally practical to standardize a system that is applicable to all areas.

The accepted definition of the diversity factor in a supply of electrical energy is "the result of the sum of the consumers' maximum demands, divided by the combined maximum demand upon the system."

When energy was principally used for lighting purposes, this factor was of considerable importance, as by its use it was practical to fix the annual assessment, and divide it into a daily use of the consumers' maximum demand.

Assuming that by dividing the standing costs of an undertaking by the maximum demand upon the system the cost was found to be £16 per kw., and the ascertained diversity factor was 1·5, and the selling price of energy 1d. per unit, then the charge to the consumer was $(16 \div 1{\cdot}5 \times 365) + 1$d. per unit for one hour's use of each kilowatt of maximum demand, the result being 8d. per unit, all further use being charged at the selling price of 1d. per unit.

The maximum demand system became practically standard for lighting uses of electricity, but the great difficulty in explaining its operation to the consumer sufficed to act as a deterrent to progress, and, as a sacrifice to simplicity, departures were made by reducing the primary charge with a corresponding raising of the secondary charge, or by the institution of a flat rate based upon average use.

In this manner the inherent equity of the original system was stultified, and the consumers at once became divisible into "bad" and "good" from the supplier's point of view.

As good consumers must of a necessity compensate for bad consumers in any solvent business, the cultivating of electricity supply became subject to the laws of expediency, and as progress has been made in power supply and more recently in heating and cooking and other uses of electricity, the law of equity has apparently been more and more lost sight of.

It is bad for municipal trading that this state should have been evolved. It is the law of equity that teaches that one ratepayer (or class) should not benefit at the expense of another, or that one consumer of electrical energy (or class) should not benefit at the expense of another.

There is apparently no reason why every consumer should not utilize the service to such an extent as to make a return in full, as nearly as may be, to the undertakers of the cost of such service, and it is to be expected at the hands of the administrators of the supply so to adjust tariffs as to conform with the laws of equity.

This can best be done by studying the conditions of *each class of supply in each individual area upon its own merits*, and estimating the relationship of the demand for each class to the actual maximum demand upon the system.

Assumption and experience must, to a large extent, control these estimates. Apart from Public Lighting, internal business lighting, and what is known as the 100 per cent. load factor power supply, all other demands are more or less subject to the application of diversity factors.

In Poplar, which is an industrial area, the following scale has been adopted, viz. :—

Nature of Demand.	Diversity Factor.
Public Lighting	Unity.
Business Lighting, internal	Unity.
Business Lighting, external	1·2
Intermittent power	2
Domestic Lighting, general	2
Domestic Lighting, occasional	8
Cooking and Heating	20

The maximum demand occurs between 4.30 and 4.40 p.m.

At this particular period the whole of the public lamps are in lighting, and at first consideration a unity factor appears to be correct. But it must be taken into consideration that in some of the streets mains are laid from which little other demand than for public service is made, carrying with it capital and administrative charges; therefore a slightly higher charge has been considered admissible to cover this cost.

Business Lighting.—The charge is assessed on watts installed, it being assumed that a consumer does not instal lighting points unless required, and that all internal lighting will be in use at the period of maximum demand. It is not the usual business practice to light up externally until later in the day, and by dividing the ascertained standing cost per kw. by 1·2 any discrepancy lies in favour of the undertaking.

This is an instance where the difference in conditions of supply between different undertakings is most pronounced. In many areas external business lighting is in full demand over the peak load, and no deviation from the unity factor is permissible, but in a locality where the supply is given under similar conditions to Poplar, in order to encourage external business lighting the tariff might be adjusted by the adoption of a diversity factor of 4 or 5 without prejudice to the interests of other consumers.

Intermittent Power.—The assessment on power supply is subject to other considerations than in the case of lighting. Every works of any importance instals a certain amount of power as standby both in regard to number and size of motors. It must be left to the discretion of the manager and his committee to make allowance for this standby. As a general rule 75 per cent. of the total kilowatts installed may be taken as the normal load, but what may be termed the internal diversity should be considered in each case on its merits.

The diversity factor of two has been taken as the relationship of the normal load to the maximum demand, as it is generally found that motors are slacking down gradually from 3 p.m., therefore at 4.30 to 4.40 p.m. not more than one-half of the connected normal power load is likely to be in use at that time.

Experience only can prove the efficacy of this assumption, but in a case like Poplar where the power load preponderates it has been fairly well proved. Out of a total sale of 16,716,705 units, of which 2,665,135 units were supplied under bulk conditions, and 921,918 units for public lighting purposes, the local power output was 11,284,056 units, whilst for lighting and other purposes within the area the supply amounted to 1,845,596 units. Therefore, of the private supply within the local area, no less than 86 per cent. was for power purposes, and, notwithstanding the high price of coal prevailing during last year, the annual surplus was practically double that of any preceding year. This increase is not totally attributable to increased business, as more efficient generating sets were brought into use during the year, but the improvement may be stated as 3 and 2 due to increased efficiency and increased business respectively, which sufficiently proves the efficacy of the tariff bases.

It has not come within the province of the Poplar undertaking to deal with any 100 per cent. load factor supply, but the author has no hesitation in stating that any tariff

based on a greater diversity factor than unity, would not produce results equivalent to those obtained from an intermittent supply on the bases quoted. Such a load is eminently attractive to the supply manager, and very often great concessions are granted in order to obtain the load, but these concessions do not bear justification, and should receive very great consideration before being granted.

Domestic Lighting.—A distinction has been drawn between general and occasional lighting. The demand has been assessed upon watts installed, and occasional lighting is generally understood to include bedrooms, cellars, offices and upper landings.

In fixing the diversity factor at two for general lighting regard was had to the fact that under ordinary circumstances the whole supply would not be in use at 4.30 p.m., and at that time a certain allowance must be made for visiting and shopping. In purely residential areas it would perhaps be unwise to allow for this margin of diversity, but in the Poplar area the figure is capable of expansion, and when revising tariffs a wider diversity will no doubt be allowed.

For occasional lighting the factor of eight is not unreasonable, and certainly admits of many additional points being installed which otherwise would be left out.

Cooking and Heating.—Perhaps the most difficult problem to consider in tariff framing is an equitable charge for the demand for cooking and heating.

It is obviously unfair to make the assessment on watts installed. The cooking outfit in one residence may be on a liberal scale, and include heating elements that are not called into requisition for every-day use, whilst in another, where first cost is of greater importance, daily use may be given to all the elements comprising the outfit. The type of cooker also has some bearing upon the assessment; a rapid heater, although involving a greater demand, is used for shorter periods, and, therefore, the diversity is increased.

The demand for heating also largely depends upon the liberality of the installation. A consumer who can afford to instal radiators in each room where required allows for a greater diversity in use than one who only instals one radiator, to do service for the whole residence.

However, there should be no difficulty in framing a scale to allow for these varying conditions.

In assuming a diversity factor of twenty, three peak times had to be considered. The daily power peaks occur at 11 a.m. and 3 p.m., as nearly as may be, and, by the lighting peak converging upon the power load, which produces the maximum demand, a third peak is created in early winter at 4.30 p.m. or thereabouts. The load at 12 mid-day is reduced to some extent during dinner time, but the bulk of the drop is at 1 p.m., which lasts until 2 p.m. It can be reasonably assumed that cooking operations will not commence until after 11 a.m., nor be continued after 2 p.m., therefore the probability of a heavy increase in the day peak is remote, but the acquisition of a load to fill the gap between 11 a.m. and 3 p.m. is most important. It may, however, be assumed that the demand will be felt at 4.30 p.m. when preparing afternoon tea and the workers' evening meal, but the loading required for the preparation of these meals is considerably less than for the mid-day meal, and the circumstances already alluded to of visiting and shopping in the afternoon must naturally affect the demand.

Taking everything into consideration, it is not unreasonable to assume that less than one-twentieth of the capacity of cookers installed will be in use at 4.30 p.m. on that particular day when the maximum demand occurs.

In dealing with this question, it has also to be borne in mind that the cooking load will almost invariably, in an industrial area, be largely supplied through mains practically

unaffected by the demand for power, therefore the additional load imposed upon the system will involve capital expenditure principally on plant and buildings.

The demands for cooking and heating appear to hold out possibilities perhaps as great as that for power. It needs no great prophetic spirit to forecast large supplies of this nature in the immediate future, due to the immense strides made in the production of heating appliances during the past year, and the promise of still further improvements shortly.

Supply managers and electricity committees should now be prepared to meet these prospective demands, and for organized competition with gas.

That cost of supply is the dominating factor must not be lost sight of. It is certainly an asset to be able to point to other advantages accruing from the use of electricity for cooking purposes, but the most important point is that the cost of supply should not exceed that of a similar service with gas.

The author submits that the price of electricity when in general use for lighting and cooking should not exceed ¾d. per unit, competing with gas at 2s. 6d. per 1,000 cubic feet, or thereabouts. In fact, in order to beat gas competition out of the field, this price should permit of the inclusion of hire of cooker, heaters and wiring installation, in order to encourage that liberality of use necessary to ensure the supply being profitable.

Bearing in mind the bases of charges laid down in this paper, the following example will illustrate the position :

A moderate-size residence of £26 per annum rateable value required a gas service for cooking and lighting costing approximately £10 per annum.

To replace this, twenty-two various lights and a 2·4 kw. cooking outfit were installed.

The cost of the service, meter, and wiring installation was £20 5s. 4d., and the cooking outfit £8 10s. 8d.

The total number of units supplied during twelve months was 3,128.

The annual assessment was, on the Poplar tariff, 0·352 kw. general lighting at £4, 0·32 kw., occasional lighting at £1, and 2·4 kws. cooking at 8s., amounting to £2 14s. 7d.

The cost of energy, 3,128 units at 0·5d., amounted to £6 10s. 4d., making a total charge of £9 4s. 11d. or 0·71d. per unit.

The hire of the service (12½ per cent. on cost) amounted to £3 12s. 11d., bringing the total bill to £12 17s. 10d., or 0·99d. per unit.

It will be seen that the supply of energy alone compared favourably with the cost of gas, but in order to obtain the supply it was necessary to expend £28 16s., which, of course, must be expected to produce an adequate return.

The author has no hesitation in stating that for prudent reasons the annual charge on account of this expenditure is greater than the anticipated cost. The basis of ten years' life of service, meter, installation and cooker is undoubtedly too short, but regard was had to the accepted terms of ten and twelve years granted by sanctioning authorities for meters and services, and the unstable type of cooker then in the market.

Promise is now given of a reliable cooker at a cost of £6, and experience shows that the average life of services will probably reach thirty years, and that twenty years may be presumed as the life of wiring installations and meters of first-rate workmanship.

Furthermore, by dealing with this class of work on a greatly extended scale, the prime cost may be expected to be considerably reduced.

Viewing the situation from this standpoint, the service charges are amendable as follows, viz. :

		£		s.	d.
Service	say	3	30 years	2	0
Meter and Installation ..	,,	16	20 years	16	0
Cooker		6	10 years	12	0
Interest at 3½ per cent. ..		25		17	6
Annual Charge				£2 7	6

Making a reduction of £1 5s. 5d. on present charges.

It is also anticipated that the fixed charge per annum will bear a reduction at an early date from £8 per kw. of maximum demand to £6 per kw., and that the diversity factor of two for general lighting may be equitably extended to three, which would halve the general lighting standing charge, and reduce the occasional lighting by 1s. 7d., and cooking by 5s., making a further reduction of £1 0s. 8d.

Taking the revised basis of charge, the following annual result is arrived at, viz. :

	£	s.	d.
Fixed Annual Charge	1	13	11
3,128 units at 0·5d.	6	10	4
Or 0·63d. per unit	8	4	3
Service Charges	2	7	6
Or 0·81d. per unit	10	11	9

at which price not only will the supply of energy compete successfully with gas, but the disability of competing with a rival power already in possession of the field will be removed.

The author is anxious that the Association should carefully review these figures, with the object of bringing to light any flaw there may be in his logic. He is convinced

that it is only by the adoption of tariffs based upon some such standard as he has endeavoured to enunciate that the cooking and heating load will be successfully tackled and brought into the practical sphere of electricity supply.

It is to be anticipated that, in the discussion, it will be pointed out that, although thirty years may be the useful life of services, and twenty years of meters, the fact remains that only twelve and ten years are allowed for repayment, but it must be remembered that it is advocated in the policy of electricity undertakings that these restrictions in the supply should be strenuously resisted, and combined action taken to remove same.

As a matter of fact in the policy of the Poplar undertaking it has been recognized that it is financially unsound to raise loans for any periods under twenty years, and not only have the loans on account of meters been completely redeemed, but all expenditure on account of services has been taken from revenue since 1909.

In view of future developments, this policy may be the means of retarding progress as the demand for the supply might possibly exceed the amount of revenue available for utilization in connecting up consumers, but the principle is sound, and if efforts to secure reform at headquarters of the sanctioning authorities are of no avail, it must be apparent that as the volume of business increases the sum available for the purpose must also increase.

The Division of Costs Necessary in Determining Fixed and Running Charges.

In making an investigation of the varied costs which comprise the total cost of supply imposed upon an undertaking, it is necessary to dissect same under three distinct headings :

First, the service cost, or the individual charge on the undertaking directly attributable to each consumer ;

Secondly, the fixed cost, or the total sum necessary to carry on the undertaking, irrespective of the amount of energy supplied ; and

Thirdly, the running cost, or the actual cost of supplying a unit of energy after making provision for service and fixed costs.

Service Costs.

Some recognition of this cost has been made in the past, as a consumer is generally required to guarantee a minimum consumption during a given period at a high unit charge, or a certain revenue for a period of years, contingent on cost of making connection, or a lump-sum payment.

But it is now generally recognized that in order to compete with other forms of power, light and heat, it is necessary to completely wire premises, particularly when the consumer is a tenant only, and install cooking and heating apparatus on hire at an initial expense to the undertaking.

Unless an undertaking is prepared to adopt this system, the universal use of electrical energy will be retarded, and progress made only in a limited degree.

It should be apparent that it is essential to charge for the complete service in such a manner as to make all transactions of this nature self-remunerative, otherwise, if the ordinary revenue of the undertaking is encroached upon to assist in meeting expenses, the consumer who has laid down his own installation must be penalized unfairly.

Should, however, each consumer be assessed in accordance with the actual cost entailed by his individual demand

no undue hardship is placed upon any, and the necessity to make a minimum charge, guarantee a given revenue, or pay a lump sum down is obviated.

Experience will prove the approximate "life" of each cost included in the service. The author has assumed that the average "life" of the connection to mains, meter, wiring installation and cooking and heating apparatus is amply covered by an equal annual payment over ten years, plus $2\frac{1}{2}$ per cent. equated interest. This is considered a safe provision, but, in order to cheapen the supply, it may be found practical to extend this period.

The business element introduced into this policy must be apparent when it is considered that the volume of work executed is governed by the profits of the concern when the cost is taken from revenue and, as the addition of every consumer should add to the amount available for service charges, progress is accelerated proportionately to the expenditure in this direction.

One important feature in connection with service costs, which must appeal to the competitive spirit usually found imbued in every electricity supply manager, is the reduction of these costs to a minimum. In the ordinary course, when expenditure of this description is charged to capital account, the necessity for minute supervision of costs is not always felt, but by a policy such as indicated, whereby the number of consumers connected up each year is governed by the amount available for this purpose, the necessity for reduction in costs is more keenly appreciated.

Hitherto, engineers have principally devoted their attention to the reduction in cost of generation in order to supply at the cheapest possible rate, but the reduction in service costs is of considerably greater importance to-day. Reduced cost of generation is generally achieved by *increasing* capital expenditure, but the desired effect in service costs is chiefly brought about by *saving* capital expenditure.

The majority of engineers would advocate the expenditure of a fair amount of capital in order to effect the saving of, say 5 lbs. of steam per kw. hour. With coal evaporating 8 lbs. water per lb. of fuel, costing 15s. per ton, this saving is equal to 0·05d. per unit.

The supply to a domestic consumer of, say, 3,000 units per annum on a system with 80 per cent. efficiency of distribution is cheapened by 15s. 0½d.

Assuming that the service to the consumer embracing connection to mains, meter, wiring and cooker costs £30, under normal conditions, but by contracting on a larger scale, and exercising closer supervision, this cost can be reduced by 25 per cent., and by careful discrimination in the selection of materials and apparatus the "life" can be extended to fifteen years instead of ten years, the service charge would be lowered from the present rate of £3 15s. per annum to £2 5s., which is double the saving effected by a reduction of 5 lbs. of steam per kw. hour, while the capital employed instead of being increased, would be considerably lowered.

Fixed Costs.

The law underlying the allocation of fixed costs may be briefly stated as follows :—

All charges upon an undertaking of any description—other than service costs—which can be accurately stated, or which can be approximately stated at the commencement of each financial year are fixed costs.

The sum of the charges thus stated, divided by the maximum demand made by the consumers as a whole, will produce a cost per kilowatt chargeable annually to each consumer, governed by the diversity factor of each class.

The author suggests that the charges on any undertaking can be allocated on the following lines, viz. :—

Interest and Redemption.—An accurate statement of the charges on existing loans for land, building, plant and mains can be prepared at the commencement of each financial year. The loan charges on services, meters, wiring and cooking installations (if any) are chargeable to service costs.

It is generally practical to fix a date for taking up new loans during the ensuing period of twelve months, therefore additional charges can be fixed approximately.

Interest on bank overdrafts and consumers' deposits, which cannot be definitely stated, is chargeable to running costs, but interest on reserve accounts, when such funds are employed as working capital, can be readily fixed.

Capital charges peculiar to Poplar and Stepney at the present time, where standby plant is shared between the two undertakings, can be debited or credited, as the case may be, to fixed costs, as notice must be given at the commencement of each financial year as to the extent of standby supply required during the ensuing period of twelve months.

Management Charges.—Movements in salaries of officials are generally defined prior to the commencement of the year, and there does not appear to be any reason why additions to staff necessary to cope with the work of the coming year could not be settled at the same time.

Insurances are payable annually in advance, and the date of payment can be made to coincide with the financial period. Insurance on extensions to plant and buildings can be approximately stated without difficulty.

Central establishment charges, and the wages of permanent workmen employed in the establishment, such as

storekeepers, timekeepers, watchmen, etc., are fixed, overtime and temporary employment being chargeable to running costs.

Law costs, compensations, printing, stationery, advertising and sundry establishment charges, being of an indefinite nature, are running costs.

Rent, Rates and Taxes.—Rent of land, property, the use of circulating water, water meters and wayleaves for cables are well defined prior to the financial period.

Rates are liable to a certain amount of fluctuation, but the assessment of the undertaking should not vary during the year, and the rate can be stated approximately.

Income tax, being dependent upon the profit realized, is a running cost.

Distribution of Electricity.—Repairs to services, meters and installations are chargeable to service costs.

Attendance at sub-stations, being of a permanent nature the wages can be definitely stated, and overtime and supplementary attendance charged to running costs.

Inspection of mains in undertakings of any importance is generally carried out by permanent hands, and the charge, therefore, is fixed.

Repairs to sub-station plant and buildings may be carried out by the permanent staff of the generating station, and the ordinary time employed is a fixed charge, but overtime, casual labour and necessary materials become a running cost.

All repairs to mains, including wages and materials, become running costs. Although the work may be carried

out by a permanent staff, the necessary amount of time is unknown beforehand, and the labour is drafted from work which is not entered in the revenue accounts of an undertaking.

Station Repairs and Maintenance.—The wages of permanent hands are chargeable to fixed costs, but all overtime, casual labour and materials used in effecting repairs are running costs.

Wages at Work.—The wages payable to the running staff are fixed, but all overtime and temporary labour is chargeable to running costs.

Engine Stores, Water, etc.—The whole of these costs are running.

Coal, Destructor Steam and Energy Purchased.—Under this heading the allocation of fixed and running costs may be somewhat difficult, as the fixed cost will vary according to the size of the station.

The working arrangement between Poplar and Stepney rendered this comparatively easy, by comparing the coal consumption at Poplar during a first summer quarter when supplying the local area only, and the consumption during the following quarter when supplying one million units to Stepney. By dividing the extra units into the extra coal used, and therefore ascertaining the running cost of supply, it was found that the standing cost equalled approximately 1,000 lbs. of coal per hour.

The application of this quantity has been made over a course of years with the following results :—

	1913–14.	1912–13.	1911–12.	1910–11.	1909–10.	1908–9.
Units generated from coal ..	18,556,384	12,619,658	10,523,338	9,954,787	8,816,888	7,164,208
Coal used ..	Tons cwt. 26,567 8	Tons cwt. qrs. 21,894 11 3	Tons cwt. qrs. 18,086 11 1	Tons cwt. qrs. 18,288 4 2	Tons cwt. qrs. 16,140 13 2	Tons cwt. qrs. 14,409 17 2
Lbs. coal per B.T.U. ..	3·218	3·886	3·85	4·15	4·1	4·5
Running lbs. Coal per B.T.U. ..	2·746	3·192	3·015	3·225	3·107	3·282

The approximate accuracy of the standby cost may be gauged by the steady figure obtained as running cost each year from 1908–13, when the running plant in use was practically standard, viz., 1,000 kw. turbo alternator sets.

Last year considerable advantage was gained by the installation of 3,000 kw. sets, hence the reduction in running costs to $2\frac{3}{4}$ lbs. per unit.

It is of important interest to note that with the smaller output of 7,164,208 units generated the standing loss was 1·218 lbs. of coal per unit, but with the vastly increased output of 18,556,384 this loss was reduced to 0·472 lbs.

The prior date coincides with the introduction of the Point Five System at Poplar. Had the distinction between standing and running cost for coal not been fully recognized, the introduction of the system must have been deferred until a later date.

On the 1908–09 figures the total cost of coal alone amounted to 0·354d., but by the transfer to standing costs this figure was reduced to 0·258d., while the remaining running costs brought the total figure up to a fraction over ·3d. per unit.

The logic of charging ·5d. (after providing for all other costs by the assessment of a fixed charge per annum) is obvious. On a five million output the calculated margin is about £4,000 per annum, but allowance must be made for "bad" consumers, discounts and bad debts. The actual result in that particular year was £3,668 gross and £2,702 net. Had the total cost of coal been taken as running cost the result would have been £2,000 less. The advantage of a definite knowledge of the fact that any increase in consumption would cost 0·1d. per unit less than present cost was of the utmost importance in fixing the selling price of energy.

The relative difference between running and total cost of coal decreases in proportion to the increase of output. With exactly the same plant in use in 1912–13, and the output doubled the difference amounted to 0·06d. per unit sold, but still an appreciable figure in calculating cost of supply.

The author has recently been repeatedly challenged to prove the commercial soundness of the principle underlying the sale of energy at prices below the total cost of production.

An ounce of fact is worth any quantity of theory, which is the excuse for publishing the annexed abstracts from the accounts of the Poplar undertaking for the past year, in such form as to embody as far as possible the theory of the system of charging now promulgated.

Assuming that the consumer agrees to pay the ascertained individual proportion of the amount included in column 1 of the "Allocation of Income," and his assessed proportion of the annual sum as made up in column 2 of the Allocation of Expenditure, then any price received greater than his proportion of the costs made up in column 3 (Expenditure) *is profit.* This proportion is usually readily ascertained by dividing the sum by the total units sold, which is ·303d, but under the special circumstances of Poplar supplying a quantity of energy in bulk to the neighbouring borough of Stepney, the correct application is made by dividing the figure set against expenditure in column 3 of the "Allocation of Profit and Loss" by the number of units sold for private purposes, when the true cost of supplying energy only for private purposes is found to be 0·311d. per unit.

Under "Allocation of Profits," a surplus is shewn in column 1 which is entirely disproportionate to the corresponding column under "Allocation of Expenditure," but it must be borne in mind that no loans are now raised for "service" expenditure, and no "interest and redemption" has been incurred since 1909, therefore the surplus shown under this head is always available for the extension of the policy adopted of providing new sevices and wiring installations out of Revenue.

ALLOCATION OF EXPENDITURE.

	1. Service Costs.	2. Fixed Costs.	3. Running Costs.	4. Total Costs.	5. d. per B.T.U. Gen.	6. d. per B.T.U. Sold.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.		
CAPITAL CHARGES: REDEMPTION	305 2 4	10,756 7 8	—	11,061 10 0		
Interest on Loans	174 18 10	10,355 18 7	—	10,530 17 5		
Bank Interest and Consumers Deposits	—	—	215 2 11	215 2 11		
Interest on Reserve Funds	—	20 19 0	—	20 19 0		
Cost of Raising Loans	—	—	48 11 6	48 11 6		
Accrued Charges	—	—	81 9 3	81 9 3		
	480 1 2	21,133 5 3	345 3 8	21,958 10 1		
Less Standby Charges	—	1,100 0 0	—	1,100 0 0		
	480 1 2	20,033 5 3	345 3 8	20,858 10 1	0·243	0·3
MANAGEMENT CHARGES:—						
Salaries	—	1,725 5 6	—	1,725 5 6		
Printing and Advertising	—	—	450 2 7	450 2 7		
Central Establishment	—	171 14 0	—	171 14 0		
Insurances	—	257 9 0	—	257 9 0		
Law Costs	—	—	23 17 7	23 17 7		
General Establishment	—	1,598 6 8	604 5 3	994 1 5		
			Cr.			
	—	3,752 15 2	Cr. 130 5 1	3,622 10 1	0·042	0·052
Rent, Rates and Wayleaves	—	4,125 1 1	—	4,125 1 1	0·048	0·06

DISTRIBUTION :—						
Inspection of Mains	—	197 12 0	—	197 12 0		
Repairs of Mains	—	—	229 5 10	229 5 10		
Repairs of Services	62 12 3	—	—	62 12 3		
Repair of Meters	95 19 6	—	—	95 19 6		
Repair of Installations	52 5 10	—	—	52 5 10		
Repair of Sub-Stations	—	68 13 10	424 8 8	493 2 6		
Contingencies Sub-Stations	—	200 0 0	—	200 0 0		
Attendance Sub-Stations	—	1,142 3 9	—	1,142 3 9		
Distribution Salaries	—	724 6 6	—	724 6 6		
	210 17 7	2,332 16 1	653 14 6	3,197 8 2	0·037	0·046
REPAIRS, ETC. :—						
Maintenance of Buildings	—	90 7 2	169 5 9	259 12 11		
Engines and Boilers	—	564 9 6	802 14 3	1,367 3 9		
Electrical Plant	—	75 1 11	61 18 3	137 0 2		
Instruments	—	12 0 5	7 13 2	19 13 7		
Contingencies	—	200 0 0	—	200 0 0		
	—	941 19 0	1,041 11 5	1,983 10 5	0·023	0·029
WAGES :—						
Generating Wages	—	2,458 2 0	439 2 1	2,897 4 1		
Generating Salaries	—	1,165 2 8	—	1,165 2 8		
	—	3,623 4 8	439 2 1	4,062 6 9	0·047	0·058
Water, Stores, etc.	—	—	421 10 9	421 10 6	0·005	0·006
Coal	—	2,770 1 6	16,129 3 3	18,899 4 9		
Destructor Steam	—	—	1,947 14 4	1,947 14 4		
Energy Purchased	—	—	274 17 1	274 17 1		
	—	2,770 1 6	18,351 14 8	21,121 16 2	0·245	0·303
Total Expenditure	690 18 9	37,579 2 9	21,122 11 9	59,392 13 3	0·69	0·853
d. per B T.U. Sold	0·01	0·54	0·303	—		
d. per B.T.U. Generated	0·008	0·437	0·2456	—		

ALLOCATION OF INCOME.

	1. Service Charges.	2. Fixed Charges.	3. Running Charges.	4. Total Charges.	5. d. per B.T.U. Sold.
		£ s. d.	£ s. d.	£ s. d.	
PRIVATE LIGHTING :—					
88,178 Units at 5d.	—	1,653 6 9	183 14 1	1,837 0 10	
277,974 „ at 4d.	—	4,053 15 9	579 2 3	4,632 18 0	
350,597 „ at 3d.	—	3,652 1 1	730 8 2	4,382 9 3	
20,599 „ at 2½d.	—	171 13 2	42 18 4	214 11 6	
91,476 „ at 2d.	—	571 14 6	190 11 6	762 6 0	
270,036 „ per agreements	—	1,064 3 9	562 11 6	1,626 15 3	
1,098,860	—	11,166 15 0	2,289 5 10	13,456 0 10	
Less Discounts and Allowances	—	—	431 1 4	431 1 4	
	—	11,166 15 0	1,858 4 6	13,024 19 6	2·845
DOMESTIC SUPPLY :—					
746,736 Units	—	4,306 11 9	1,555 14 0	5,862 5 9	1·884
POWER SUPPLY :—					
1,235,556 Units at 1½d.	—	5,148 3 0	2,574 1 6	7,722 4 6	
10,048,500 „ per agreements	—	13,554 7 1	20,934 7 6	34,488 14 7	
11,284,056	—	18,702 10 1	23,508 9 0	42,210 19 1	
Less Discounts and Allowances	—	—	436 3 2	436 3 2	
	—	18,702 10 1	23,072 5 10	41,774 15 11	0·888

SUNDRY CHARGES :—					
Meter Rents	28 11 5	—	—	—	
Minimum Charges	—	371 19 8	—	400 11 1	
	28 11 5	34,547 16 6	26,486 4 4	61,062 12 3	
12½ per cent. on Cost of Services, Meter and Installations	2,695 16 1	2,695 16 1	—	—	
	2,724 7 6	31,852 0 5	26,486 4 4	61,062 12 3	
Less Bad Debts	—	—	94 8 6	94 8 6	
Total Private supply, 13,129,652	2,724 7 6	31,852 0 5	26,391 15 10	60,968 3 9	1·114
PUBLIC SUPPLY :—					
Lighting 921,918 Units	—	1,982 5 2	1,920 13 3	3,902 18 5	1·016
Bulk - 2,665,135 ,,	—	—	2,776 3 8	2,776 3 8	0·25
Total - 3,587,053 ,,	—	1,982 5 2	4,696 16 11	6,679 2 1	0·447
Total supply 16,716,705	2,724 7 6	33,834 5 7	31,088 12 9	67,647 5 10	0·971
EXPENDITURE	690 18 9	37,579 2 9	21,122 11 9	59,392 13 3	0·853
Surplus	2,033 8 9	—	9,966 1 0	8,254 12 7	0·118
Deficit	—	3,744 17 2	—	—	

ALLOCATION OF PROFIT AND LOSS.

	1. Service.	2. Fixed.	3. Running.	4. Total.	5. d. per B.T.U.
PRIVATE SUPPLY :—					
Income	2,724 7 6	31,852 0 5	26,391 15 10	60,968 3 9	1·114
Expenditure :—					
13,129,652 Units sold					
796,046 ,, used in works					
2,690,246 conversion and distribution.					
16,615,944 Units generated at 0·2456d.	—	—	17,003 13 0	53,291 9 4	0·311
Service Costs	690 18 9	—	—	—	0·012
Fixed Costs	—	35,596 17 7	—	—	0·651
Surplus	2,033 8 9	—	9,388 2 10	7,676 14 5	0·14
Deficit	—	3,744 17 2	—	—	
PUBLIC SUPPLY LIGHTING	—	1,982 5 2	1,920 13 3	3,902 18 5	1·016
921,918 Units sold.					
55,780 ,, used in works.					
188,502 conversions and distribution					
1,166,200 Units generated at 0.2456d.	—	—	1,193 8 3	—	0·311
Fixed Costs at £9 per kw.	—	1,982 5 2	—	3,175 13 5	0·516
Surplus	—	—	727 5 0	727 5 0	0·189

PUBLIC SUPPLY, BULK: - - -	—	—	2,776 3 8	2,776 3 8	0·25
2,665,135 Units sold. 33,314 1¼ per cent. Transmission - 161,874 used in works.					
2,860,323 Units generated at 0·2456d.	—	—	2,927 1 3	2,927 1 3	0·263
Deficit - - - - - - -	—	—	*150 17 7	150 17 7	0·013
Total Surplus - - - - - -	2,033 8 9	—	9,964 10 3		
Total Deficit - - - - - -	—	3,744 17 2	—	8,254 12 7	
Decimal Adjustment - - -	—	—	1 10 9		
Income from Property - - -	—	—	—	61 19 4	
Profit, Sales Department - - -	—	—	—	193 13 2	
Net Surplus as per Accounts - -	—	—	—	8,510 5 1	

* An apparent loss is shown in connection with Bulk Supply, but an examination of the items constituting Running Costs will show that a number do not apply to "Bulk" (Printing, &c., Distributing Costs, etc., etc.) but they have been included in the allocation of Profit and Loss for the sake of uniformity. Furthermore, the price of 0·25d. is fixed subject to a coal clause and the equalising sum received has been credited to the cost of coal.

Under column 2 of the Allocation of Profits there is a deficit of £3,744 17s. 2d. clearly proving that some class or classes of supply are under-assessed.

It has doubtless been gathered that the method adopted for arriving at the income is by allocating ·5d. per unit to running charges and 12½ per cent. on the initial cost to service charges, thereby arriving at the fixed charge by deduction.

The author in his own mind has no doubt as to the true explanation of this deficiency. The Poplar system of supply was originally laid down for lighting purposes, similarly to many other undertakings throughout the country, whereas the three extensions made during the past ten years have been necessary owing to large demands for power. It would have been suicidal to the interests of the undertaking if the full proportion of the original capital cost had been imposed upon power consumers. But the system of charging adopted ten years ago, viz., £4 per kw. of demand plus ·5d. per unit, or a maximum rate of 1½d. per unit has been maintained to date (excepting in the case of large consumers where a scale of discounts off the running charge is in vogue ranging from 2½ per cent. on annual consumption from 250,000 to 500,000 to 10 per cent. for over 1,000,000 units) whereas the charges for private and public lighting have been modified from time to time as progress permitted, and the present system of domestic supply introduced.

The author is confident that in the course of another year a proper balance will have been struck, and thence onwards the fixed costs all round will bear reductions as the plant and distributing system become loaded to a greater degree of density.

Author's Conclusions.

An attempt is hereby made to place before the responsible managers, lay and technical, of municipal electricity undertakings, a system of charging which, by adaptation, is possible of application to any area of supply, and therefore claim can be made to a step forward in the direction of Standardization of Tariffs.

No attempt is made to claim that there are no weaknesses in the system, but the author does emphatically contend that the weaknesses are reduced to a minimum compared with any other system of charging whether for electricity, gas, water, or other public services.

It is humanly impossible to attain the ideal, but because it is so there is no reason why an effort should not be made to approach the ideal as nearly as may be.

It is to be anticipated that criticism will be made in regard to the human tendency to exceed the number of watts allowed for in the fixed charge; the difficulty in properly assessing the demand where a number of radiators and other domestic utensils are installed; and the opportunity for giving preferential treatment in making assessments. These are weaknesses undoubtedly, but all other systems embody similar weak points without laying claim to the many advantages which are inherent to this system.

There is no reason why, because in a few instances the installation of additional watts may escape the vigilance of the undertaker's officials, a system should be adopted which allows the consumer to instal as many watts as he may think fit for a given sum; or that a scale of charges should not be arrived at according to the number of radiators or omnibus plugs included in an installation; or that an independent Committee should not be appointed to act as assessors to whom the public would have the right of appeal if unfairly assessed; or that the official auditors should

not become sufficiently versed in electricity finance to point out where a consumer may have been under-assessed.

Should this system ever become standardized two fetishes of the electricity world must go by the board, viz., "Diversity Factor" and "Load Factor."

Diversity has been exhaustively dealt with in the main contention of the paper, but a final word upon the value of "load factor" is necessary.

The principal feature of the system outlined is that each consumer obtains the benefit of his own load factor, or in other words, the "good" consumer does not make up for the "bad" consumer.

Hitherto the ideal load obtainable has been that of 100 per cent., the maximum demand of an individual extended over the whole 8,760 hours of the year.

The cooking load offers totally different possibilities. An individual load factor of 10 per cent. is quite usual, but where the diversity is 20 the value of the class is double that of the 100 per cent. individual load factor consumer.

Probably this statement will sufficiently explain the reason for low rates for domestic supply.

The paper would not be complete without reference to what might appear to be an important omission in connection with charges for a universal supply of electricity, viz., the prepayment system.

The author has purposely refrained from introducing this phase of the supply because of the fact that little data are as yet available. It is proposed to go well ahead in Poplar very shortly, but the scheme is not well enough advanced to place before the members.

Roughly, the outline of the policy is as follows, viz. :

Mains will be laid in every thoroughfare at the earliest opportunity, thus entirely eliminating gas from the streets.

In connecting up the first objective will be tenement buildings, which present the least initial outlay per head of the population.

The service will comprise wiring for lighting, and include, where desired, hotplate, cooker or radiators.

The consumers will be divided into three classes, viz. lighting only, lighting and hotplate, and lighting and cooker.

Payment will be obtained through penny coin meters at a rate according to the demand of each class.

The cooking class will probably be charged at the inclusive rate of 1d. per unit (lower if possible), but an average monthly use of a given number of units must be registered or the meter will be changed to the hotplate class at, say, 2d. per unit, also with a minimum monthly use from which transfers would be made to the lighting class at, say, 4d. per unit, beyond which, being the maximum rate for lighting, it is impossible to go.

As stated, this is a rough outline, which may be improved upon as experience is gained, but recent developments in cooking and heating appliances warrant steps being taken to cater for the requirements of the poorest classes of the community.

At first sight these proposals savour somewhat of a departure from the equitable law which is upheld to govern charges for supply. The circumstances are different to any other supply, and demand special consideration.

In anticipation of the demand, the author has had for some time past various types of prepayment meters for testing purposes. Originally he favoured the idea of, and

has had specially made, a differential meter which would change over after the insertion of a given number of pence at a higher rate than ·5d. per unit, which would, with a certain monthly use at a high rate, return to the undertaking the fixed charge based on the cost of the installation, and then allow of the continued use to the end of the month at the running charge only.

The great objection to such a system is that at the end of a month a consumer would probably be obtaining energy at the rate of ·5d. per unit, but on the first and following days of the following month would have to pay 4d. or 2d. as the case might be. It was recognized that any such system would find ill favour with the working classes, as it would be impossible to explain the ethics governing such procedure.

However, in order to preserve equity throughout it is practical to endorse on each consumer's card a number of units to be used each month, after which a return will be made to the consumer of the difference between ·5d. and the rate at which energy is being paid for. Thus, if 250 units per month at 1d. per unit is considered a fair return for a cooking and lighting supply a refund of 2s. 1d. would be made if 300 units were found to have been consumed

This appears to be the most practical method of adjusting charges under the prepayment system, but the author will be glad of any suggestions that might occur to members at the Convention.

The author regrets the extreme length of this paper, but considers that the importance of the subject warrants the large amount of detail necessary fully to explain the principles evolved. The subject has received a great amount of his attention during the past six or seven years, and also of his assistant manager, Mr. Fred. Tait, whose financial ability and assiduity in attention to detail has enabled him to be of material assistance in arriving at the conclusions set forth in this paper.

DISCUSSION ON MR. BOWDEN'S PAPER.

Mr. C. H. Wordingham (Admiralty) said this subject rather appealed to him in this way. They were trying to sell a product and to get money for it, and all the juggling in the world would not prevent people having to pay for what was being sold to them, and therefore it was no use trying to dodge the fact that if people were to use electricity they must pull out money. That seemed to be rather lost sight of ; there seemed to be a sort of idea that people could be induced to think that they were not going to pay for it. He quite agreed with the author that the primary object of municipal electricity supply was to bring about the universal use of energy for power, lighting and heating at the lowest possible cost, and that these undertakings should not be looked upon as a milch cow for the rates ; but he did not agree with the remark early in the paper, that any available profits might be taken to provide special public improvements, apparently for a memorial theatre, or something of that kind. This was quite inconsistent with the author's previous view that profits should not be taken to relieve rates. The proper thing to do was to put all profits back into the undertaking. The author seemed very confident as to the passing of gas cooking and heating. This remained to be seen. Perhaps cooking would go, but heating he was very doubtful about. The author stated that " the law of continuity of supply renders it imperative that mains, services and meters shall always be kept in a perfect state of efficiency." Personally he believed that continuity of revenue as well as the continuity of supply would depend upon the maintenance of meters, etc. The author was sound where he contended that if these things were maintained in a high state of efficiency, the period of the loan ought to be a long one, but he went rather far when he suggested 100 years. It was quite true that posterity had done very little for them, but he did not think they could go so far as to pile up debt and never wipe it out. He could not quite follow the author when he said :— " These are matters for consideration at the hands of electricity committees, which must be well defined before the responsible manager can attempt to evolve an equitable tariff." This rather implied that the tariff was to depend on the amount of profit ; but surely the equity of the method of charging determined the system. He could not see how it could depend upon the profit. A tariff was either right or wrong in principle ; they might not get enough revenue to make a profit, but the equity of the tariff

was surely determined on broad principles. With regard to the statement that " While it may be true that the laws of expediency govern private enterprise, it should never be lost sight of that municipal enterprise is governed by the laws of equity," his only comment on that was " ha ! ha ! " He would like a little instruction with regard to the term " diversity factor," which had grown up since his central station days. Mr. Bowden stated that the accepted definition of diversity factor is the ratio of the sum of the consumers' maximum demands, divided by the combined maximum demand upon the system. He thought it was the other way about, namely, the ratio of the actual demand to the sum of the connected demands. The author was not quite consistent, because he rather laid down that each class of consumer ought to be charged in proportion to what it costs the station—with this he quite agreed—but later on in the paper the author stated " but in a locality where the supply is given under similar conditions to Poplar, in order to encourage external business lighting, the tariff might be adjusted by the adoption of a diversity factor of 4 or 5 without prejudice to the interest of other consumers." This rather went to show that when it was a question of expediency, even the author was not quite true to his principles. The same thing occurred later in the paper, where it was stated " For occasional lighting the factor of eight is not unreasonable and certainly admits of many additional points being installed which otherwise would be left out." That again was expediency. He did not say that expediency was wrong, but most makers of tariffs would, he thought, have to admit, that they were based on expediency. He would like to say one word of agreement with the author with regard to the system of charging by the rateable value of the house. There was nothing much to add to what was said in the paper on this point, but he fully concurred that it was an entirely inequitable and wrong basis, and he still firmly held to the old original Hopkinson system of charging. He did not think anything would ever come up to it. It was perfectly sound scientifically, and he knew it could be worked in practice. It did not so much matter whether the consumer understood it or not ; what the consumer did understand was his bill, and if he found by the Hopkinson system that he was charged less than by a flat or some other rate it was all he wanted to know in the long run.

Mr. F. M. Long (Chief Electrical Engineer, Norwich), whilst agreeing that the paper was a very valuable one indeed, said he did not think many members would have much difficulty

in finding some points upon which they disagreed with the author. The author had evolved his tariff on the principle of equity. Whilst agreeing with this, we must not lose sight of the fact that what might be equitable from the seller's point of view would not always appear equitable from the buyer's point of view and it was no use for the purpose of business, to have a system which produced the impression upon the consumer that he had been cheated. Take a simple example. A man started with a 1 kw. radiator in his house, for which Mr. Bowden would charge him 8s. a year. He used this first in one room and then in another, but in order to save himself the trouble of moving it about he put in another radiator. Mr. Bowden would want to charge him another 8s. a year, but the man would very reasonably object, on the ground that he was still practically only using one radiator at a time, and why, therefore, should he be charged for using two. He believed there would be many cases of that sort, which would arise when a fixed charge was based upon the amount of apparatus installed. He did not think such a basis at all necessary. With the high diversity factor obtained with a cooking load, current could be supplied at a flat rate, and in most cases at ½d. As he had pointed out in a paper before the Association two years ago, the bulk of fixed standing charges at the present time—in many cases amounting to £10 or £12 per kw. on the maximum demand—were made up of interest and sinking fund on machinery and plant, which cost far more than had to be paid now. It was possible to add to plant nowadays at a very much lower rate, something between £3 and £4 per kw., and he thought it would be found that where the running costs were about 3d. or below, a cooking load could be added at a total cost of less 5d. certainly in towns where a large proportion of the cooking was at midday. There was no need to charge the old high standing costs against a cooking load. In competition with gas, electricity was in a much more favourable position with regard to lighting than heating and cooking. Where we could get 3d. a unit for lighting we could only get perhaps ½d. for heating purposes; therefore they could put all the high standing charges against lighting, and looked at in this way it was possible to take on any extra cooking without much fear, at a low charge. An ideal system must, of course, have a fixed charge of some sort, and for business premises it was necessary to take the kilowatts installed as the basis, but another basis was available in the case of private houses which could certainly be treated as a class by themselves, since they formed something like three-quarters of the total

possible consumers. Although at first sight the rateable value might not appear to have anything to do with the demand for electricity, if it were worked out it would be found in many towns that the rateable value did bear a very close relationship to the demand which a consumer would make for lighting his house. An example of Mr. Bowden's tariff was given on page 20, and he would like to compare that with the rateable value basis of charging. Mr. Bowden arrived at the figure of £2 14s. 7d. as the total fixed charge for this house, which was said to have a rateable value of £26 per annum. On the rateable value system of charging with seconding charge at ½d. per unit, and 15 per cent. as the primary charge, the figure for the latter would be £3 18s., but that included a service and the meter, which would have an initial cost of say, £6, and consequently Mr. Bowden's charge of £2 14s. 7d. would have to be increased by 15s. to allow for this, making £3 9s. 7d., against £3 18s. Then again, Mr. Bowden did not include a radiator, which the occupier would be allowed to use in the case of the rateable value system, and another 8s. would have to be added, making £3 17s. 8d. or practically the same in both cases. Therefore he maintained that practically the same result was arrived at under the rateable value system in a very much simpler manner, and one which appealed, he believed, very much more to a consumer, who liked to know what he had got to pay, and who did not trouble himself about the basis upon which it was calculated.

Bailie W. B. Smith (Glasgow) said he was in general agreement with the principles laid down in the paper, and especially that the electricity department should not be complicated with the rates. A company supplying electricity or gas did not pay anything towards the relief of rates, and why should a municipal trading concern be in a worse position than a private concern in that respect. The effect of transferring profits to relief of rates was this. In many towns some manufacturers had put their boilers out of action, and had taken power from the Corporation electricity department. In Glasgow hundreds of firms had done this. Other manufacturers had not touched their boilers, and had chimneys which were very often polluting the atmosphere, and in winter time caused death to the population. The man who had shut down his boiler plant and took electricity not only paid for his current, but under the present bad system actually paid a certain proportion of the rates of the man next door, who was working on the bad principle. That surely was unfair. Why should this manufacturer have to pay something to the

Hospitals Rate when it was the man next door that was causing much of the ill-health of the town ? Municipal electricity departments need have no profits if they did as was done in Glasgow, where they balanced the accounts year by year, and on the result of that balance, and on the coal estimates, fixed the charges for the following year, leaving the barest possible margin of profit. This had been done, and it had been found that for lighting there was just a fraction of a loss, whereas for power there was a fraction of a profit, and the two balanced together, leaving only just enough to keep on the right side. He suggested that the convention should pass a resolution—if it were in order—that in the I.M.E.A. Bill a clause should be inserted, prohibiting the use of electricity profits for the relief of rates. There was a precedent for this in the Glasgow Consolidated Bill in connection with the Glasgow Corporation gas undertaking, when the House of Lords struck out a clause enabling surpluses to be devoted to public services, on the ground that the clause had been in existence for forty-six years, but had never been put into force, and consequently could not have been needed.

Councillor J. W. Crowther (Sheffield) said as a business man who had had thirteen years' connection with what was certainly not the smallest undertaking in the Kingdom, the conclusion he had come to so far as the development of the industry was concerned was that for lighting purposes there was a tremendous field which was as yet unexploited, and he could give a few figures which might be of interest in this connection. On March 25th last there were in Sheffield 107,288 houses rated, and out of these 91,811 were under £15 per annum annual value ; 6,827 had a rateable value of between £15 and £20 per annum ; 3,299 were between £25 and £30 per annum ; 1,703 were over £30 per annum ; and the larger premises, up to the millionaire, of which there were a few in Sheffield, numbered 3,618. The rate books showed that of the 91,811 houses under £15 per annum, practically none took electricity ; of the £20 to £25 houses, 35 per cent. were supplied ; of the £25 to £30, 40 per cent. were supplied, and of the houses above that value, from 65 to 70 per cent. were supplied. Therefore it could fairly be said that at present electricity was a luxury of the rich rather than a necessity of the poor. In his attack upon the rateable value system, Mr. Bowden had mentioned that houses from £13 to £20 could be compounded for, but he had overlooked the fact that this only applied to property of an annual rateable value of £7 or less, and therefore that argument was completely swept away. It

was also stated that shopkeepers were unfairly charged on the rateable value system, but in Sheffield they made concessions to shopkeepers, and offered current at 2d. instead of 4d., and so they would be put upon equal terms with the rateable value system. Another factor which Mr. Bowden took into consideration was the price of gas. Reference was made in the paper to gas at 2s. 6d., but in Sheffield they had to contend with gas at 1s. 3d., and that made it impossible for them to standardize tariffs. It was necessary to make the charges as far as possible compare favourably with the price of gas. Finally Mr. Bowden spoke of the law of equity. In his opinion the law of equity worked very badly in most cities. For instance, if the profits of the undertaking were utilised in relief of rates, preferential treatment was being given to a class of citizen who required it least. As he had already pointed out, there were 91,811 houses in Sheffield rated at £15 and under, but not one of these people got any relief from rates. It was the landlord who took it, and the others who lived in the houses at the higher rateable values. It was necessary to aim at having a tariff system which was financially stable; secondly, to maintain a high standard of efficiency; and thirdly, to give economy of service. Having done that, he believed the rateable value system was the only system that was going to get electrical undertakings into the houses that at present were not taking electrical supply.

Mr. H. Richardson (Chief Electrical Engineer, Dundee) said he would like to counteract the author's optimism about the sale of current for cookers. He might be wrong, and it might be the point of view forced upon one's mind through working in an industrial area, but his opinion was that until the industry got hiring powers the cooking load must be regarded as a mere bagatelle. Without these hiring powers he did not believe much progress would be made, because whether a man was earning £100 or £10,000 a year, he and his family had been taught by the gas people to hire such things as cookers, and the electrical people would have to hire them in the same way. With regard to the price of cooking, he had found in his own house that at ⅞d. electricity competed well with gas at 2s. 2d. There might be reasons for that as regards the type of cooker, but he failed to see that it was necessary to go down to ¾d. per unit for heating and cooking to compete with gas at 2s. 6d. He would like to add one more "ha! ha!" to Mr. Wordingham's on the question of expediency. He agreed with the rateable value system, provided the circumstances of the town in which it

was proposed to apply were very carefully considered beforehand, because in all towns it would not do. He had tried to apply it in Dundee, but had failed. In an old city like his he was up against this sort of thing,—Two brothers living in different parts of the town, both having the same sized families, and living in the same sized house, but one house having a rateable value of £30, and the other a rateable value of £50, and the one naturally failed to see why he should pay more for lighting the same sized house than the other. In most cities, however, he believed it would do. If they were trying to aim at perfection they would never get it in that way, but it they tried to make themselves a little less exact in these commercial matters than they did in their engineering matters they would do better. He pleaded for "simplicity, simplicity, always simplicity" in these matters, and did not agree with Mr. Wordingham that the consumer did not worry about how his bill was calculated so long as he could understand the amount.

Mr. A. S. Blackman (Chief Electrical Engineer, Sunderland) said as the first manager at Poplar, and having been responsible for putting down the original plant there, he congratulated the author upon the phenomenal results that he had obtained therein—and he said it with all respect—in a working-class district in the East End of London. It rather showed that those who spoke as Mr. Richardson had just done with regard to the future of electric cooking were looking upon the thing from a too pessimistic point of view. It rather showed that those who held views similar to Mr. Richardson's did not know what was going on, and if they would visit Poplar and see what Mr. Bowden had done there they would have their fears dispelled.

Mr. Richardson, rising on a point of order, said he had not the slightest doubt as to the future of electric cooking. He had every faith in it, and had only mentioned that it could not be fully developed until we got the I.M.E.A. Bill. That was the difference.

Mr. Blackman, continuing, said that the success which Mr. Bowden had achieved at Poplar was sufficient proof that there was nothing very far wrong with his tariffs, although in detail he might join issue with him upon several points. For instance, he thought Mr. Bowden was unnecessarily handicapping himself

in sticking to his kilowatt charge, when he had ready to hand the more simple and more easily applied rateable value system. Mr. Bowden stated that he did not agree with another department of the Corporation assessing the standing charge for electricity consumers, but the rateable value system did not mean that at all. It was the electricity department which assessed the percentage the consumer had to pay, and the fact that the electricity department made use of the scale of assessments already in existence was not a valid argument that the electricity department was handing over to another department of the Corporation the fixing of the consumers' standing charges. A point which had struck him was with regard to the radiators. It was painful to him to hear people talk about 1-kw. radiators. In Sunderland they sent out 1-kw. radiators, and the result was nothing but dissatisfaction. People either sent them back, or they fell into disuse. They had now gone forward, and were putting out nothing but 3 and 4-kw. radiators, and the result was absolute satisfaction. In Sunderland gas was sold at a very low rate, but he found that at ½d. he was doing a large amount of heating, and it was going ahead very rapidly. With regard to tariffs, and the cultivation of these commercial instincts which were being continually dinned into their ears nowadays, he suggested that they should take a leaf out of the draper's book and deal in fractions of a penny. It was stated that the Scotsman who introduced the pricing of goods at 11¾d. had retired on a fortune. In Sunderland they fixed their tariff at 1⅞d. for public houses, and he had now got every public house and hotel on their mains. Indeed, there were frequent applications to extend the mains for public house purposes, and it was actually beginning to be a grievance for any public house or hotel proprietor if he could not get an electricity supply. In the same way he had outside shop lighting at 1⅞d., and for a shop that would light throughout they charged 2⅞d. They had not yet made their fortune in Sunderland, but it was an asset in the hands of the convasser, and enabled him to get business. The actual standardization of tariffs he regarded as a counsel of perfection, but the point to keep in mind was the price of gas, which, after all, was the main thing against which they had to compete. There was no standardization in the price of gas throughout the country, and he failed to see how we could expect to get standardization in the charge for electricity.

Councillor Sinclair (Swansea) said he could not agree with the title of the paper, because he believed that if they lived to the age

of Methuselah they would never obtain standardization of Tariffs, although they might by some means or other obtain some standardization of method. He entirely agreed with Mr. Blackman as against Mr. Richardson. At Swansea they had not much cooking at present, but it was constantly extending, and he did not think the future of electric cooking would wait for any Parliamentary Bill. It had to come; in fact, it had come, and it was going to stay. Both systems of charging which had been discussed were simple, but he could not say that they were ideal, because they appeared to him in no way to contain the equity claimed. If the rateable value system was taken, it depended upon the size of the man's house as to what he was charged per unit used, and a curve he had, showed that the smaller the house the less the price paid per unit, and he could not see where the equity came in. The maximum demand system had its complications, it was not understood, but it worked very well; indeed, there was more equity in it than there was in the rateable value system. With regard to the system by which there was a charge per kilowatt of apparatus installed, one man might like a lot of light and fill his house with lamps, radiators, cookers, &c., and consequently he would pay more per unit for his current than the man who was more economical in plant installed. That again was not equity. Another point was that undoubtedly the increase in the future in the heating and cooking load would all depend on the price, and by making the price suitable there would be no difficulty in getting customers. He believed the time was shortly bound to come when the electrical engineers and managers would have to give up all idea of peak load or maximum demand, and the fear of having insufficient copper in the ground, and sell to any consumer current for any purpose he desired at a cheap rate. If he was afraid of his peak load he must get more plant, and if he was afraid of the copper in the street, the sooner he put more in the better for the undertaking.

Councillor A. H. Dykes (Beckenham) said he would confine himself to one interesting point which was mentioned by Councillor Crowther of Sheffield. As chairman of a council he was exceedingly anxious to extend the benefits of electricity to the greatest possible number of houses in the district. With the conditions prevailing that day they could all appreciate what it must mean in small stuffy rooms to have gas or petroleum lamps burning; moreover, the poor man, with his two or three rooms, paid for his gas or oil lighting three times as much per

light as those who used electricity. Surely there was something wrong when the large number of some 90,000 houses in Sheffield had not got electric lighting. Mr. Bowden had shown that electrical undertakings could afford to supply these houses at a cheap rate. With the existing tariff at Poplar taking a 30-watt lamp, and the kilowatt charge of £4 per annum, the annual charge would be 2s. 7d. The ordinary consumer used about 12 units per lamp, which Mr. Bowden suggested should be charged for at ½d. per unit, making a total of 3s. 1d. The small man, however, with his three or four lamps, would use, say, treble that quantity, making a total figure of 4s. 1d. He did not know whether any of them had the figures, but he knew that a penny placed in a penny-in-the-slot gas meter in most towns in England would not burn one gas lamp for a winter's evening. It was nearly always necessary to put in a second penny. Similarly with oil it was difficult to get through one evening on a penny. Some weeks ago in one of the electrical papers there was an account of what Mr. Tomlinson Lee had been doing at Wimbledon, where some 5,000 lamps, every one of which was previously supplied by penny-in-the-slot gas meters, had been put upon the mains. These represented 1,000 consumers, and he believed he was not betraying any secrets in saying that the increase in revenue was something over £1,000 a year, and that by the end of the present year it would probably be nearly £2,000. The general argument against dealing with this class of consumer was the cost of putting in meters. But why have a meter? It was true that with the unlimited supply system some consumers might use more current than others, but this would not necessitate more plant at the station, nor an increase in the size of the mains in the street. Neither did these few extra units increase supervision or wages. It simply meant that a little more fuel had to be burned. Particularly in A.C. stations these extra units would really only cost ¼d. a unit for fuel. Therefore, what was the sense in putting in a meter, reading it, keeping it in order, and ascertaining whether a man with four lights was going to burn an extra 20 or 30 units per annum. It cost considerably more to read the meter than the extra units cost. With regard to the services, Mr. Lee got over the difficulty of cost by running the service into the first house in a row, and looping through sometimes into as many as twenty houses from the one service. Although the system had only been in operation for some eighteen months, the number of lamps connected per service was 22 or 23, and it was increasing every month. This had been brought about by an arrangement with the Fixed Price Light

Company, who dealt with the consumers direct on the basis of so much per lamp per week. At Wimbledon it was 3½d. in the winter and 2½d. in the summer, and the electricity undertaking had nothing whatever to do except to draw a cheque from the Company each quarter. That was what was done at Wimbledon, and enabled the consumers to get their lighting at a considerably cheaper price than by any other means.

Mr. A. Nicholls Moore (Chief Electrical Engineer, Newport, Mon.) said he thought the first part of the paper was open to very grave criticism on many grounds. The author would appear to waive altogether the inherent difference between private trading with subscribed capital and municipal trading depending for its capital on loans raised on the security of the Borough Funds. The debatable point as to the right or otherwise of the ratepayers to share in some way the profits accruing from a successful electricity undertaking cannot be so lightly brushed aside as the author suggests, seeing that it is only upon the security of the rates that any municipal undertaking is enabled to trade at all. The suggestion that the question should be eliminated altogether from electricity politics seems illogical. It was also to be regretted, in view of the fact that so many members of Committees and Councils were present at the meeting, that such views should be advanced. After all, they had to deal with Committees and Councils, and if they once got it into the minds of members of Councils that they were endeavouring by some means to overcome the local opposition of the Gas Company by cutting down prices irrespective of the rates and the ratepayers, they would only create an opposition which would be most injurious not only to the furtherance of their schemes, but to the undertaking. The author's remarkably advanced views on the question of loan redemption should certainly provide food for thought to all central station engineers, and might be commended to the careful observation of the Local Government Board. He even goes so far as to suggest interminable loans or at least loan periods approaching 100 years. It seemed to him this was a most vicious policy and prompted by the desire to postpone liabilities and place them almost entirely on the shoulders of future generations, and from a desire to entirely disregard the principles of municipal trading and to run a municipal undertaking as if it were a private concern. On this question of loans, if the author's ideas were adopted, there would be an ever-increasing accumulation of capital to be wiped out. It is more particularly to be condemned

in view of the fact that beyond a casual reference he has not attempted to discuss the question of depreciation, nor did he even make any proposals for the setting aside of ample depreciation and reserve funds. He went so far as to suggest there is no necessity to create anything more than a small contingency fund to meet possible fluctuations in the price of coal and abnormal maintenance of plant, and he is particular to point out very cleverly that this sum under his scheme would be as small as possible, so that it would not be worth the consideration of the local Finance Department. Why should the question of an asset-producing revenue free from debt be so lightly dismissed as the author suggests? Although the Local Government Board may have gone to the extreme, yet in his (Mr. Moore's) opinion their policy is a sound one and calculated wtih a view to the ultimate placing of electricity undertakings on a stronger and more sound basis than in the past. If the author's policy were to be adopted, it seemed to him that in due course undertakings would find themselves landed with such heavy charges on capital account that their last condition would be worse than the first. There is, moreover, no likelihood of future generations being relieved of their liabilities and obligations by so-called excessive payments by the present generation. In suggesting that this is so the author has overlooked the fact of the steady growth and possibly abnormal growth that will take place in all provincial towns, necessitating on the part of those to come heavy expenditures not only for the replacement of existing plant, but very large additions thereto. In my opinion it is essential to create a sinking fund, and if possible also a reserve fund, which shall assure the replacement of capital borrowed on the security of the local rates within a reasonable period.

There were several points in the paper on which the author seemed to be most contradictory. This seemed to be a general failing of his, and he was afraid the author did not make any bones about it. Reference had been made to expediency. It was stated that good consumers must of necessity compensate for bad consumers in any solvent business, and as Mr. Bowden's business appeared to be absolutely solvent, he must be making his good consumers compensate for the bad ones. In this he agreed, but it was contradictory to what was said later on in the paper in the general conclusions, one of which read as follows: "It is to be anticipated that criticism will be made in regard to the human tendency to exceed the number of watts allowed for

in the fixed charge. The difficulty in properly assessing the demand where a number of radiators and other domestic utensils are installed; and the opportunity for giving preferential treatment in making assessments. These are weaknesses undoubtedly, but all other systems embody similar weak points without laying claim to the many advantages which are inherent to this system." This explained exactly what Mr. Bowden was after, viz. equity plus expediency. The whole of Mr. Bowden's theory was based on diversity factor. This was a very nice thing, but the author stated that, " should this system ever become standardized, two fetishes of the electricity world must go by the board, viz. diversity factor and load factor." He hoped they would, but at the same time they must not overlook the load factor. This was a point which Mr. Bowden had certainly very much overlooked. Looking through the Poplar accounts, it would be seen that the net profit from cooking and heating was only £600, and Mr. Bowden himself stated that it was due to his power load that he attributed his remarkable increase in revenue. Thus it was load factor, and not diversity factor, which was responsible for the improved results at Poplar, where 86 per cent. of the load had the very large load factor of 33 per cent. Therefore Mr. Bowden's great success at Poplar is due to the very fact which he really seemed to ignore, namely, load factor. He seemed to make a deathbed repentance on the last page, where he stated " Diversity had been exhaustively dealt with in the main contention of the paper, but a final word on the value of load factor is necessary." It was the poor load factor of the cooking load which accounts for the fact that with an allocation of charges of £4,000 on account of fixed charges and £1,500 running costs, the small net profit of £600 already referred to was made on the cooking and heating. Mr. Bowden invites criticism on his figures on p. 21. If these figures are to be criticised properly, then it should be done in conjunction with his allocation of accounts, from which it will be seen the average price obtained for heating and cooking load was 1.38d. per unit on fixed charges, yet in the hypothetical case cited the fixed charge was taken at 0.13d. per unit and the hypothetical case cannot therefore be a fair average case. Then it was stated elsewhere in the paper that repairs to services and meters must be debited to service costs, but he could not find anywhere in the hypothetical case any debit on this account. The author's methods of allocating charges appeared also most inconsistent and haphazard, and he seemed to have ignored the very carefully considered methods of allocation that had already been set out

by a special committee appointed to consider the question. Surely the author had fallen into a very simple error when he attempted to show that the saving on services by careful "discrimination in the selection of materials and apparatus" could be made equal to double the saving effected by a reduction of 5 lbs. of steam per kilowatt hour. In one case they were dealing with the saving effected on upwards of 18,000,000 units as against the saving effected on a very small number of units in comparison. He felt sure that the author, when he came to consider his paper again, would realise that he was entirely wrong in his conclusions on this point.

Mr. J. W. Beauchamp (Chief Electrical Engineer, West Ham) said that whilst a great deal was heard about equity and the just treatment of consumers, he had never noticed that the consumers put themselves to any great trouble to treat the supply department with remarkable justice or equity. One point upon which he differed from Mr. Bowden was where he looked forward to the time when electricity would be supplied at a fixed charge without any secondary or running cost. He did not say that it could not be done; as a matter of fact, it was done in some places now, but he saw no particular reason for doing it, and regarded it as a bad thing. There was no justification for giving anybody something for nothing if that something was of any value to him. The second charge for units might fall to a very small figure, but even so, that figure should be obtained, because no two consumers would use the same amount of electricity for the same kilowatt of demand, and under Mr. Bowden's scheme an injustice would be done to those who used the least amount. Mr. Bowden seemed to get away from the subject of the value of service. This was always associated with Mr. Seabrook, and there was a great deal in it. It was perfectly common-sense trading which applied to every business, namely, to try and find out what a commodity was worth to a man, and then to get that price out of him. It was a mistake to give electricity for less than they would pay, because by doing so they were simply depriving themselves of a surplus which in his opinion might be applied to some monument of the electrical undertaking, such as more generous street lighting. He did not believe in giving money to the rates, but in some circumstances a surplus might be devoted to the object he had suggested, on the principle of a sprat to catch a mackerel, and street lighting had a good advertising value. In discussing the rateable value system he thought they had been rather getting off the true line of

discussion. The question did not seem to him to be as to whether those persons who were using the rateable value system were charging enough, or whether they were going to lose money. There was no doubt that there was considerable relationship between the rateable value of domestic premises and the average bill for electric light, but there were notable exceptions to this, and he thought it was not right for another department to be able to alter the assessment of probably five-sixths of their consumers account. It was true that the electricity department could alter the percentage, but that could not be called an ideal tariff. Furthermore, they did not know what future legislation would do, for instance, with regard to local taxation. He knew very little about this, but had been told that the Budget had foreshadowed to some acute person that there would be some different way of raising money as between the assessment of land and buildings, and this might knock such a tariff all to pieces. He realised that because the system was so simple it was in danger of becoming a fashion, and therefore he suggested that it might be used for a time whilst it suited them, but merely as an internal indicator rather than anything else. He objected to declaring to the consumer that they charged him so much a year, representing 10 per cent. on the assessment of his house. He would rather tell him that the charge was for some other reason, because if the assessment changed the charge could be changed, whereas the consumer would object to his bill being increased if he knew that his assessment had been increased and that his electric light bill was based on the assessment, as he would probably argue that he was not using any more light under his new assessment than under the old one. If he did not know the basis of his charge he could not make this objection. On the other hand, he failed to see why the department should suffer because the assessment of a particular district went down. As a matter of fact, there was every probability of the consumption increasing in these circumstances, because the landlord, on account of being hard up, might take in lodgers, and so increase the consumption. One argument in favour of the system was that when the half-watt lamps came into use in small sizes the undertaking would be sheltered from its ravages. He was not sure about that. The account would fall only by half of the running portion of the charge, perhaps 10 per cent. of the total, but in view of the fact that the powerful lamp makers would undoubtedly flood the place with literature to the effect that the electric light bill would be halved again, did they think that the consumer would be content ? He did not ; be believed they would have to share some of the plunder with the rateable tariff consumer.

Mr. F. S. Grogan (British Electric Transformer Co.) said he was able to join in the discussion from the consumer's point of view, having seen how these tariffs affect the business in a great many towns. The discussion seemed to have gone upon the point between the rateable value system and the Poplar system of charging. They both had the same end in view; first of all a primary charge and then a small running charge, but the rateable value system had a very great disadvantage, because with the higher rated houses it was impossible to get the consumer to take on the domestic load, as his standing charge came out at too high a figure to start with. Again, the rateable value system introduced the same difficulties as did the income tax. They were all familiar with trying to get their income tax assessed to as low a figure as possible. In the same way the householder was always taking every opportunity of getting his rates reduced, and why should his electric light account be reduced in consequence. A very important point not brought out during the discussion was the diversity factor in dealing with the question of cooking. Mr. Bowden had referred to this as being 20, and then went on in the very last page of all to give an example, from which he gathered that a load factor of 10 and a diversity factor of 20 gave something which was equivalent to a 200 per cent. load factor on the station. He would be very happy if that could be proved, as he could not quite see it himself. Perhaps Mr. Bowden would give a figure or two to substantiate that, because he would like to see it done. The author had asked for criticisms on the paper. The only criticism he had to make, and he thought it was a *bona fide* one, was that the author had got down to rather too low a figure where he spoke of a cooker which could be bought at £6, and which he presumed had a very much higher loading than the cooker previously mentioned by the author In that case the standing charges should be increased somewhat, and therefore the figure of £1 13s. 4d., the fixed annual charge, should be somewhat higher. At the same time, Mr. Bowden brought out another very important point indeed in dealing with diversity factor on cooking stoves on another page, where he stated that he believed the diversity factor of cooking would change with different types of cookers. In that he believed the author was perfectly right, *i.e.*, with a cooker which is very highly loaded, in order to get quick initial heating of the oven, the diversity factor, with the maximum possible load on such a cooker, must be greater than on a cooker which would employ a lesser degree of loading for a long continued period. However, if the load

factor was 10, the previously assumed diversity factor of 20 must be automatically reduced, and he did not believe that finally we should get more than 100 per cent. by multiplying the diversity factor and load factor together. Perhaps the author could clear that up in his reply. With regard to the slot meters, nobody appreciated more than he did the value of slot meters for a cooking load. Such an apparatus must be used in connection with the working man, and he strongly commended them to the consideration of central station engineers. The author's suggestion that a rebate should be made by the collector had been adopted successfully by the gas companies, when the return of a few pence each time the money was collected from the meter had a very pleasing effect. Finally he congratulated Mr. Bowden on his paper, and his only exception to the general views expressed in it was where it dealt with the question of the future. The author had rather overlooked the fact that more money must be spent on mains, because there was going to be a very big domestic load; the paper rather suggested that the capital would be confined to the plant rather than the mains.

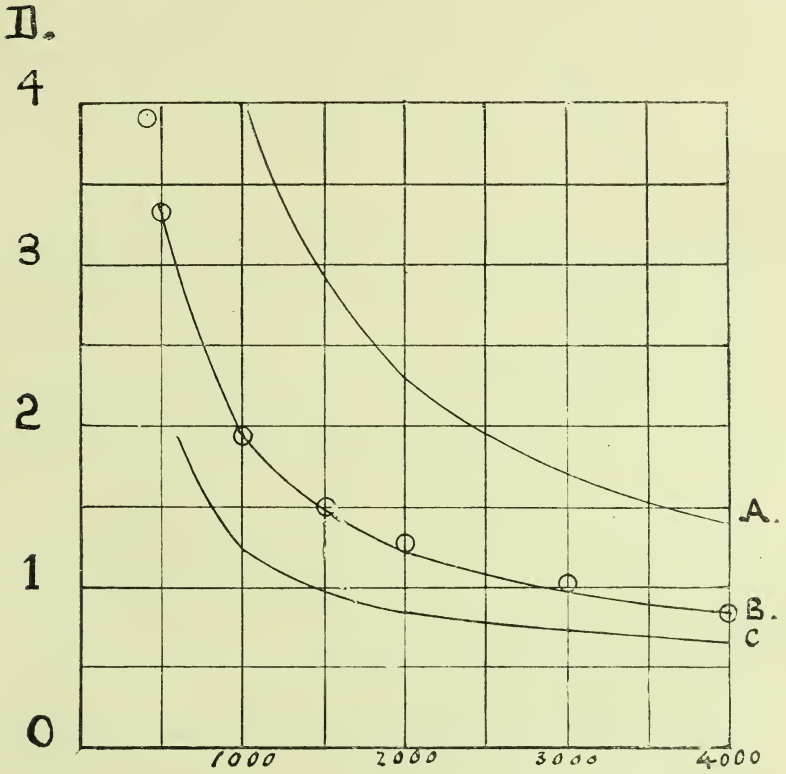
Mr. H. R. Burnett (Chief Electrical Engineer, Barrow-in Furness) said the impression appeared to prevail among some chairmen and engineers that in order to get satisfied consumers they must almost give electricity away. The difficulty had been mentioned of getting working men's houses on to the mains, but in Barrow out of about 1,500 domestic consumers, 1,000 of them were premises occupied by the artisan and labouring classes. Many of these had been supplied for about twelve years and up to two years ago they were all charged through prepayment meters at 4½d. per unit. There had been many complaints, some of which were undoubtedly due to troubles with the meters, and some to the price paid. Therefore he had instituted a system of charging at a fixed sum per week, which was roughly based on the demand and was collected with the rent, plus 1d. per unit. The effect had been to increase the consumption 100 per cent. and there were now no complaints whatever. This, he thought, proved clearly that it was possible to get a reasonable price for the supply and to have satisfied consumers. The author stated that the only attributes of the Norwich system were expediency and simplicity, and he thought that everybody would agree with this opinion. He failed to see why, if the engineer was to decide the fixed charge to be made to the consumer, he should not base this on the measured estimated demand; that left the whole thing under the engineer's control instead of putting it in the hands of overseers.

Councillor Crowther (Sheffield) said the work of the overseers had nothing to do with electric lighting, as whenever they assessed premises they did not know whether electric light was in the house or not, and therefore they did not fix the charge to be made for electricity.

Mr. Burnett said with regard to the running charge he thought it was unfortunate that many engineers had adopted as low a charge as they had done. His experience at Barrow had shown that it was possible to have large numbers of satisfied consumers at 1d. per unit. He did not say it would not be reduced, but Mr. Vignoles in his paper had worked out his running costs at 0·36d. with coal at 7s. 5d. per ton. Probably most engineers were paying nearly double that and therefore a running charge of 0·5d. per unit would certainly not allow a reasonable margin of profit for anybody paying 15s. per ton for coal. He was pleased to note that although Mr. Vignoles said he could supply at ½d. per unit, he was actually charging 1d., and he could not help thinking that some engineers either in their desire for notoriety or in order to qualify for membership of that very select body known as the Point Fives, had adopted tariffs which were not altogether justified by their costs.

Councillor Sinclair (Swansea) (*Communicated*) in amplification of his remarks at Stratford on Mr. Bowden's Paper on Standardization of Tariffs, submits the accompanying series of curves in which the perpendicular line is price per unit in pence and the horizontal line is number of units consumed per annum. The curves portray the system where 15 per cent. is charged on the rateable value of the house and ½d. per unit for all current consumed. Curves *A*, *B* and *C* represents the average price per unit up to 4,000 units per annum paid for current by consumers whose houses are rated at £100, £40 and £20, respectively. The circles in alinement with curve *B* represent an hypothetical curve built up on a series of discounts, which will be dealt with later. A study of *A*, *B* and *C* reveals the fact that the larger the premises the higher is the average rate per unit used, apparently, out of all proportion to the increased number of units consumed. It cannot be claimed that units used increases *pro rata* with the rateable value of the premises wired: a consumption curve for different rated houses is found to be anything like a straight line, therefore it follows that the larger the house the greater the price paid per unit by that particular customer.

Though not likely to happen, it is permissible to argue that three consumers, as in curves *A*, *B* and *C*, may consume 4,000 units each per annum, in which case they pay for identically the same thing—£23 6s. 8d., £13 10s. and £11 6s. 8d., respectively. A similar set of curves built up on the kw. capacity of the plant installed, plus ½d. per unit for current consumed, displays,



practically, an exact duplicate of those already discussed, so that, in the writer's opinion, neither of these systems appear to be ideal or permit of equity of charge under varied circumstances. For the maximum demand system the same objections may be levied, because the charge made depends upon the maximum demand of the individual; but from a study made of a large number of consumers' accounts of widely varying

amounts the divergency from equity of charge per unit was found to be extremely small. For the purpose of throwing out a suggestion which may lead to some fruitful discussion, the writer has compiled a curve shown by the circles along curve *B*, built up upon a fixed charge per unit of, say, 6d., subject to an increasing discount for every 100 units consumed per annum. The curve is obtained as follows:

First	100 units at 6d.		=	6d.	per unit.
For	500	,, less 44%	=	3·32d.	,,
,,	1,000	,, ,, 68%	=	1·92d.	,,
,,	2,000	,, ,, 79%	=	1·26d.	,,
,,	3,000	,, ,, 83%	=	1·02d.	,,
,,	4,000	,, ,, 86%	=	·84d.	,,

and from then on at the same rate.

In submitting above it is not intended in any way to represent such a scheme as ideal, but merely to create discussion upon Standardization of Method. Any of the above systems can be treated as quarterly instead of per annum by dividing by 4.

Mr. J. Horace Bowden (*Communicated*) states that, generally speaking, the remarks made at the meeting showed appreciation of his endeavour to say a final word on tariff framing, which, together with the subsequent comments made by the Electrical Press, prove ample recompense for the trouble entailed in collecting the necessary data in connection with the Paper.

Probably the title of the Paper was inappropriate, but the author disclaims any responsibility for the same. When responding to the invitation of the Council to contribute to the proceedings, he suggested dealing with "a universal system of charging for supply by Local Authorities," but the actual title, "Standardization of Tariffs," was decided by the Council.

He is perfectly in agreement with those members who expressed the opinion that it was impossible to obtain "Standardization of Tariffs," and he does not think that any words used in the Paper could convey that impression to members. He made use of the words in his conclusions to the effect that "an attempt is hereby made to place before the responsible managers of municipal electricity undertakings a *system of charging* which, by adaptation, is possible of application to any area of supply, and therefore claim can be made to a *step forward* in the direction of Standardization of Tariffs."

A maker of tariffs must recognize three essentials, viz. law, system and method. The law which underlies a tariff denotes the policy of the undertaking, and the author very clearly pointed out that it was essential that the Managing Committee be perfectly agreed upon policy before the manager could attempt to frame a tariff. The system of charging to be adopted must be entirely dependent upon the law or policy adopted by the Committee and Council, *and the method of applying the system is by the tariff.*

In the system advocated by the author, which may be designated the Demand System, the law of equity was taken as the first essential. Other systems are based upon the law of expediency, *e.g.* the Rateable Value System, or simplicity, *e.g.* the Flat Rate System.

A multiplicity of tariffs may be evolved out of any one of these systems, *but it is possible to standardize a system.* As a matter of fact, the trend of the whole discussion appeared to be on the merits and demerits of the Rateable Value *versus* the Demand Systems, that is to say, equity *versus* expediency.

The fact that no mention was made of the Flat Rate System is of itself a notable feature of the discussion.

The author must confess that he experienced a certain amount of disappointment that the discussion did not take the direction of quite a number of the salient features, but rather tended to be critical on minor points.

For instance, the elimination of the running charge by recouping the cost from the sale of by-products was quite a prominent feature of the paper. The equity of the method outlined might very well have been called into question, and, indeed, this has been done in the critical columns of one of the technical papers, but he would point out that the sale of by-products is governed by an entirely different law to that governing the sale of energy, viz. that of supply and demand. The selling price of sulphate of ammonia, pitch, etc., would be effected by the demand for same, and the supply available. If every undertaking were to produce these commodities, and sell in competition with gas undertakings, the probability is that present prices would fall. The price of pitch to-day is practically double that of ten

years ago, largely due to the demand created by new methods of road-making ; but if the supplies were to be doubled, no doubt the price would assume its former position.

Competition with Gas undertakings in the sale of by-products should appeal to Electricity Supply Managers, because in the coming struggle for existence it is probable that the supply of gas will be cheapened by bolstering up the price of other coal products, and so place the sale of energy at a disadvantage. It is possible that gas competition will force undertakers to lay down by-product recovery plant for the sake of self-preservation.

There is quite a reasonable distinction between a supply under a public monopoly and the sale of a product under competitive conditions.

There was also a strong point raised in respect of cheapening the supply of the consumer by increasing the life of connections and installations and contracting on a large scale in comparison with reduction in cost of generation. It was pointed out that in the first instance capital expenditure would be saved, but in the latter increased. The author's contention was not criticised in the discussion, but was called into question in the technical Press, and he would like to state in support of his argument that it is quite practical to cheapen the cost of services and installations by connecting rows of houses at a time instead of the spasmodic connections at present going on where workmen are employed on a single house in one part of the area and removed to another part perhaps miles distant. When universal supply is brought about there is no reason why the work should not be allocated in some such manner, as very few areas are as yet completely covered by the existing network.

Meters, cookers and fires can be purchased at much lower rates if orders are placed in 100 lots instead of in dozens or singly.

Perhaps the most important feature which failed to elicit any discussion was the system of dividing fixed from running costs, particularly in view of the fact that Mr. Vignoles had treated the division in a totally different manner to the author a couple of days previously.

This phase of the subject is of the utmost importance in tariff framing, inasmuch as the fixed charges can be stated with approximate accuracy at *the beginning* of each financial year, and any reduction in charges contemplated can be equitably made in accordance with the author's proposition to keep surplus profits within a reasonable margin.

Mr. Wordingham's remarks, although tending towards pedantry and sarcasm, are fully appreciated by the author in the spirit in which they were no doubt intended to be received.

There was certainly no point in the paper that warranted the assumption that an attempt was being made to juggle with charges so as to hoodwink the consumer. People must, of course, pay for the use of electricity, but a consumer, who in municipal enterprise is a part shareholder in the concern, is entitled to demand equitable treatment when charged for his supply. He is also entitled to assume when electing representatives to manage the undertaking that their first care will be his interest.

The author fails to understand Mr. Wordingham's accusation of inconsistency in advocating the disposal of surplus profits for specific purposes of public improvement, or how he would propose to put back *all* profits into the undertaking.

Particular mention was made in the paper that the author considered it financially unsound to borrow money for less than twenty years, therefore, when considering the tariff each year provision is made at present for the purchase of meters, cooking and heating appliances, and the cost of services and wiring installations. In addition to these items it now becomes incumbent upon him owing to the reduction of loan periods below twenty years to provide for all plant out of revenue, but against this he advocates the extension of loan periods for mains to sixty years.

Having made provision as indicated, which is all that can legally be dealt with, prudence demands that there should be some margin of surplus, and it is only in respect of such margin (which is beyond the working of the undertaking) that he suggests should be dealt with in the manner indicated. He does not

suggest a memorial theatre, nor yet a public park, but leaves it to the discretion of the Council to utilize the fund for the public good. An ideal system would show no surplus, but leave the account equally balanced between income and expenditure. He has no pretence to the attainment of the ideal, but prefers to provide a margin of surplus to be handed over, rather than sustain a deficit which would have to be made up out of the general rate.

Mr. Wordingham expressed a doubt as to the possibility of electricity superseding gas for heating purposes, although admitting the possibility of a cooking load. The author cannot conceive of any service rendered by gas that cannot be ultimately supplanted by electricity, provided the cost of supply is sufficiently low.

The reference to the continuity of revenue being dependent upon the maintenance of meters is not happy. It is quite possible in future practice that meters may be dispensed with altogether. Should it be possible to wipe out the running cost of production by the sale of other products of coal meters will be unnecessary, and no engineer of to-day can state authoritatively that such a state of things will not be brought about. The author stated in the paper that it was towards this ideal that the lines of progress were developing, and he still adheres to that opinion.

The author did not advocate one hundred years for the mains loans, but the legal limit of sixty years. But if the law could be amended so as to allow one hundred years' loans for electricity purposes, he would undoubtedly advocate the extension to mains in addition to any other purpose. It is impossible to follow Mr. Wordingham's remark regarding "piling up debt and never wiping it out." If mains are maintained and renewed when necessary out of revenue the debt is wiped out by the process of the sinking fund whether for thirty, sixty, or one hundred years. The sinking fund is established for the protection of posterity, but if the loan period is unnecessarily short the consumer during the sinking fund period is injured and posterity benefited proportionately.

It is impossible to follow Mr. Wordingham's remarks upon the "equity of the method of charging determining the system."

Equity is the law which determines the system, and the tariff is the method of applying it. The Electricity Committee (and Council) must lay down the law whether it be equity, expediency, or simplicity. If it be decided in favour of equity, then each consumer should pay as nearly as may be the cost of the service which he demands. The manager is responsible for recommending the system which appears to be most equitable, and from his knowledge of the locality, and the nature of the various classes of demand he can frame a suitable tariff. The tariff must include the amount of profit determined upon, and if the revenue did not produce a profit the tariff would be wrong in conception.

Mr. Wordingham's satirical " Ha, ha ! " as his comment upon equity and its status in municipal enterprise appears to be absolutely out of place when he winds up his remarks with an eulogy on the Hopkinson method of charging. If ever any method of charging for a public service was based upon the laws of equity in a superlative degree, it was that which emanated from Dr. Hopkinson, and if the undertaker of to-day was concerned only with the supply of light, the author would have had little to say in disparagement of the same. The multifarious uses to which electrical energy can be placed to-day, and the further possible uses of the future, demand that a system shall be established which can be applied to universal use, but the essential principle of the system must be that no use or uses shall be bolstered up to the detriment of any other use or uses which the author claims for the system he has endeavoured to set out.

The author agrees that the application of diversity factors has outgrown Mr. Wordingham's central station days. He endeavoured to be explicit, and he thinks that careful reading of the definition is sufficient, and he is not prepared to make any amendment as suggested, but he would like to state that " *the* diversity factor " has now no place in electricity finance.

The author fails to see why he can be accused of not being true to his principles by adopting a diversity factor of four or five for outside shop lighting in an area where the maximum demand occurs at 4.30 p.m. If the interests of other consumers are not prejudiced, that is to say, if the supply can be given at the cheaper rate and still show a proportionate margin of

profit, such a charge is equitable, and if by the reduction in the charge the supply can be increased ten or twenty-fold it is the proper business course to adopt, as, in his estimation, the value of outside shop lighting as an advertising medium is of great importance.

There was a further comment which does not appear in the shorthand notes. Mr. Wordingham stated that "statutory obligations compel an undertaker to connect up consumers" in reference to the advocacy of wiring premises out of surplus profits, but he overlooked the fact that the author recommended a course which is not compulsory. This is business additional to the statutory supply which would of necessity be governed by the amount of surplus available for the purpose.

Mr. Long rather laboriously attempted to show that the instance given in the paper of a house rated at £26 per annum would work out with the fixed charge at 15 per cent. similarly to the Poplar method, but he overlooked the fact that no two consumers make identical demands, and to be perfectly fair it might therefore be necessary to take in one case 10 per cent., another 15 per cent., and in another 20 per cent. If each consumer is to be assessed according to his possible demand (which is done in some areas adopting the rateable value as a basis) why should such an ostrich-like method be adopted ?

Mr. Long spoke at some length on the unfairness of charging a consumer according to the number of radiators installed, but he evidently overlooked the fact that the author stated it was practical to form a sliding scale of charges where more than one radiator is installed. The fact of installing more than one radiator admits of the application of a diversity factor, the use of which was one of the principal features of the paper.

The author agrees with Mr. Long that the consumer likes to know what he has got to pay, and does not trouble about the basis upon which the charge is calculated, but he overlooks the fact that the supply manager must trouble about the basis, and that he must guard against giving preferential treatment, especially if supplying in the same area with a vigilant gas company. But there is one thing that the consumer will trouble about ; he will want to know why his neighbour, who has a

large family, or who lets apartments, making a steady demand on the undertaking in respect of every room in the house should not pay more than he does himself, with only an intermittent demand, and if he is told that he must pay in excess in order to supply his neighbour's needs, the only reasonable supposition is that he will elect to remain a consumer of gas. It is useless to tell him that he should remove to a smaller house in order to be fairly assessed according to his needs.

Bailie Smith's comments are generally in accord with the author's principles. The only point which he does not agree is that it should be necessary to go to Parliament for Powers to prevent the use of electricity profits for the relief of rates. This savours rather too much of grandmotherly legislation.

Councillor Crowther's strong point was that there is a tremendous field for lighting purposes at present unexploited, and in support of his statement mentioned that 85 per cent. of the houses in Sheffield were under £15 per annum rateable value, of which only 10 per cent. took electricity. The author is of the opinion that this field would be better left unexploited if lighting only would be used. It is only from the combined use of power, light and heat for all domestic purposes that energy can be profitably supplied to the working classes at prices which can compete with gas. The author gathered from his remarks that he would not object to supplying this class at a loss if he could be recouped from the wealthier classes, but he would point out that when the supply is given to the whole of these houses, of which there are 91,811, and each take on an average, say, 1,000 units per annum, 100 million units of the total output would be supplied at a loss, and the author cannot conceive of any class of supply which would yield sufficient extra profit to recoup this.

Councillor Crowther evidently had only Sheffield in his mind when he corrected the author's statement that houses from £13 to £20 could be compounded for. The fact that this applies only to houses at £7 and under in Sheffield does not sweep away the author's argument, as very few towns of importance would contain any houses of this low value. Councillor Crowther might have been a little more explicit with regard to the charge to shop-keepers. The author cannot conceive that the statement

made as to the charge of 2d. instead of 4d. refers to *all* shop-keepers. He can quite understand if applied to long-hour consumers, such as publicans, but a definite flat rate of 2d. to all shop-keepers alike is outside equity or expediency, its only attribute being simplicity.

Because gas is sold at 1s. 3d. in Sheffield compared with 2s. 6d. in London, it does not affect the suggested tariff system ; but it appears that coal is so cheap in Sheffield (and this was borne out by Mr. Fedden's paper, which showed that coal cost about 7s. 6d. compared with 14s. to 15s. in London) that the running charge of 0·5d. per unit should be reduced in order to compete with gas.

Curiously enough, Councillor Crowther in summing up expresses the author's opinions exactly ! " It is necessary to aim at having a tariff system which is financially stable ; secondly, to maintain a high standard of efficiency ; and, thirdly, to give economy of service." This is all the author claims to have advocated.

Mr. Richardson's remarks do not bear criticism. He pleaded for " simplicity, simplicity, always simplicity," but he was the only member to do so, and also apparently overlooked the fact that hiring powers already obtain in the author's area.

Mr. Blackman could testify to the difficulties which had to be encountered in Poplar better than any member present at the Convention, and the author duly appreciated his remarks. He could not, however, agree with the very commercial spirit which actuated Mr. Blackman in reducing his charges by one-eighth of a penny per unit in order to induce business, unless justified by a corresponding reduction in cost.

It is difficult to follow Mr. Blackman's meaning in reference to the assessment of the percentage of the rateable value which the consumer must pay. By the Poplar method each consumer is assessed upon his application, and it is essentially within the province of the supply manager to make that assessment, but if the Council decides to fix, say, 10 per cent. of the rateable value as the fixed charge the supply manager has nothing further to do with it, and the charges are subject to the dictates of the Assessment Committee. If Mr. Blackman means that he fixes

the percentage according to the consumer's possible demand, he is doing all that the author advocates, but in a less specific manner, and in a more roundabout way. The inference is that Mr. Blackman systematically arrives at the amount the consumer should pay, which is equal to so much per cent. of the rateable value.

Alderman Sinclair somewhat confuses the issue. The author agrees that literal standardization of tariffs *is* impossible, but he does not agree that his proposed system is inequitable. Surely to "sell any consumer current for any purpose he desired at a cheap rate" would be the most inequitable system of all.

In his communicated remarks he attemps to arrive at the result the Poplar method actually obtains by a series of discounts, but he does not give the basis of arriving at these discounts. The author gave explicit reasons and ample justification for his system, but Alderman Sinclair would charge at the rate of 6d. for any supply up to 100 units per annum, the next stage being 500 units at 3·32d.; but what price the consumer taking 101 units would pay he does not state, whereas the author does.

The suggested system is eminently impractical. Every unit increased consumption, with a fixed annual charge, decreases the price per unit to the consumer, which is equitable, as it is in accordance with the actual cost to the undertaking. To render Alderman Sinclair's proposals equitable a different ratio of discount should be applied to every unit used from the maximum rate of 6d. to the maximum consumption of 4,000. Assuming that ½d. per unit is a fair return to cover running cost, the suggested scale shows that the fixed charge is 100 × 5½d.= £2 5s. 10d., therefore 4,000 units should be charged at 4,000 × ·5d. +£2 5s. 10d., which is equal to 0·64d. instead of 0·84d., clearly proving that there is some confusion in Alderman Sinclair's ideas.

The author cannot agree that the use of 4,000 units per annum is not likely to happen in private houses In the example given in the paper, 3,128 units were used for lighting and cooking only. When the reduction outlined by the author takes place he anticipates that the service will be augmented by the use of radiators and fans, and possibly bath water, which would add at least 2,000 units to the annual consumption.

Councillor Dyke's remarks were somewhat irrelevant to the subject of the paper, as he dealt with the subject of lighting only, and the method adopted by the Fixed Price Light Co. The author contends that while the running cost of production stands anywhere in the region of $\frac{1}{4}$d. per unit, and the supply taken by the consumer may range from 100 to 5,000 units per annum, meters will always be required. Eliminate the running cost and meters can be dispensed with altogether, but not until then.

Mr. Nicholls Moore was more amusing than sound in his criticism, and the author does not really think that he intended his remarks to be taken seriously. He stated that the author was most contradictory, but he evidently had not thoroughly studied the paper.

The author repudiates the idea of the supply manager having to deal with the Council as well as his Committee. If the manager can convince his Committee upon any subject it is incumbent upon the Committee to convince the Council.

No statement was made in the paper relating to an ever-increasing accumulation of capital never to be wiped out. If a loan is liquidated within sixty years it is certainly wiped out at the end of that period, and beyond this period the author did not go. But even if loans in perpetuity had been advocated, a time would come when no further loans would be required, and the capital of the undertaking would be placed on a par with the shareholders' capital in a company.

The author certainly did state that good consumers must always pay for bad, otherwise an undertaking would become insolvent, but he fails to see how this statement is contradicted by his reference to " the human tendency to exceed the number of watts allowed," etc. The system advocated eliminates the bad consumer as far as it is possible to go, but some consumers would still be " bad " if the limit of 8d. per unit were charged; therefore the law admits of " bad " consumers.

Mr. Moore apparently fails to appreciate the difference between the diversity factor as understood in the early days when applied to lighting only, and diversity factors used in assessing fixed charges for a universal supply. His remarks in connection with

load factor as applied to Poplar are not in accordance with facts. Two years ago the load factor was superior to last year, and the net profit considerably less. By the author's system the benefit attached to load factor is handed over to the consumer, therefore all consumers ought to be profitable to the undertaking proportionately to the consumption, irrespective of load factor. It is the total output which affects the amount of profit.

Mr. Moore is wrong in his statement regarding average fixed charges at Poplar for heating and cooking, which he works out at 1·38d. per unit. This price includes all domestic supplies, which, in the majority of cases, is for lighting only.

He is also wrong in stating that the case quoted in the paper was hypothetical. The figures given were actual, and if he refers to the example he will find that the prime cost of service, *meter* and wiring was £20 5s. 4d., upon which 12½ per cent. is charged annually.

It is difficult to appreciate any good purpose to be served by criticisms of this nature, which can be so readily answered by reference to chapter and verse.

Mr. Beauchamp remarked that consumers did not trouble to treat the supply authority with justice or equity, but the author would point out that it is the maker of laws that must consider equity. Because the individual may evade the law, there is no justification for eliminating equity from the law.

The author did not advocate giving something for nothing. If the primary charge is correctly assessed no injustice would be done to a consumer making full use of his installation capacity with no extra charge. One would have expected the reverse criticism to this, and the author assumes that Mr. Beauchamp has been reported incorrectly; but he would point out that the by-products would increase with the greater consumption, and probably the undertaking would benefit by the largest consumption.

The suggestion to obtain from the consumer the maximum price he is willing to pay is, in the author's opinion, distinctly unsound. One consumer might be quite willing to pay a certain charge which might yield more than the requisite amount of

profit, but another might only take the supply doing similar service if the price were less. The net result might be favourable to the undertaking, but the method, besides being unfair, is illegal.

Mr. Beauchamp is not consistent, because after stating that something should not be given for nothing he advocates utilising surplus profits in supplying a more generous system of street lighting. The author submitted that all the local authority could reasonably expect from the undertaking was that all public services should be supplied on an absolutely cost basis. Mr. Beauchamp's proposal would afford relief to the rates by taxing the consumers who are willing to pay for the benefit of the community generally. The author admits the value of good public lighting as an advertising medium, but a cheap and efficient service all round is of much greater value.

The author was absolutely in accord with Mr. Beauchamp regarding rateable value, and fully appreciated his remarks in respect of the coming half-watt lamp. This was a phase he had not dealt with, and it helps to prove the adaptability of the system ; the halving of the demand would affect the Kilo-watt charge, but not the service charge, which is perfectly fair to the undertaking and the consumer alike.

Mr. Grogan did not appear to follow the reasoning in respect of value of cooking load. In the example given in the paper, the total Kilo-watts connected were 3·077, which included 2·4 kw. of cooking apparatus. The load factor of 1,000 units consumption is 11·4 per cent., say 10 per cent., allowing for a less liberal use. If a diversity factor of twenty is correct, the total consumption would be 60,000 units, and the demand on the station would be 3 kws., therefore, $\frac{60{,}000 \times 100}{3 \times 24 \times 375} = 228$, say 10 per cent. $\times$ 20 = 200 per cent. But if the loading in the cooker is doubled and maximum cooking heat is obtained in half the former time, the diversity factor would also be doubled, and the load factor halved, which produces similar results in both cases. It would appear, therefore, that the heavier loading does not depreciate the value of the supply to the undertaking.

Mr. Grogan was also guilty of criticism which can be disproved by the context of the paper. He stated that " the author had

rather overlooked the fact that more money must be spent on mains." At the very outset the author submitted that "the immediate future holds out the prospect of large sums being necessary for laying mains, and providing meters and services." It was on this account that he was so very emphatic in urging the necessity for increasing loan periods to sixty years.

Mr. Burnett's remarks gave the impression that he only considered it necessary to alter his tariff to suit dissatisfied consumers. The author was agreeably surprised to learn that many of the artisan and labouring classes were using energy twelve years ago. With current at 4½d. per unit, and carbon filament lamps in use, the consumers in Barrow must be of a wonderfully contented nature to be satisfied with the small volume of light then obtainable for one penny.

The author agreed with Mr. Burnett in his answer to Councillor Crowther's interpellation, but could not agree that the running charge of ·5d. per unit is too low. His argument regarding the cost of coal was unsound. The cost of coal used in Poplar last year was 14s. 2d., and the running cost per unit generated 0·2086d. Four years ago the cost of coal was 10s. 7¾d, and the running cost 0·1839d. Taking the extreme case cited by Mr. Burnett, where there is a difference of 7s. per ton, and assuming the high steam consumption figure of 30lbs. per unit, evaporating 7lbs. water per lb. of fuel, the difference per unit is only 0·15d., which certainly does not warrant double the charge of supply. It was significant of present-day progress that Mr. Burnett should point to Mr. Vignoles as a supporter of his argument. The author understands that Mr. Vignoles has or is at present endeavouring to induce his Committee to alter his tariff so as to qualify for that "very select body known as the Point Fives." Time alone will show whether the members of this body have allowed "their desire for notoriety" to overweigh their judgment by fixing prices not justified by costs.

A hearty vote of thanks was accorded to Mr. Bowden at the conclusion of the discussion.

Incorporated Municipal Electrical Association.

FRIDAY, JUNE 19th.

MEETING AT THE BIRMINGHAM AND MIDLAND INSTITUTE, BIRMINGHAM.

Annual General Meeting.

ELECTION OF PRESIDENT AND OFFICERS FOR 1914–15.

The President said he would ask the Honorary Secretary to explain the position with regard to the election of Council.

Mr. H. Faraday Proctor said that the new Articles of Association came into force at this meeting for the first time, and perhaps it would be as well to pass a formal resolution as to those members who continued in office, and those who retire from office at different dates. The Articles alter the number of engineer members, and also the number of committee representatives on the Council, and also alter their respective periods of office, following out what was the evident desire of the members, the Council adopted the procedure that the member of council who had held office for the longest period should be the first to retire. They would find on the ballot sheet the names of those members of Council whom

it was thought should remain on for the next year. He would accordingly put it to the meeting that the following members remain on the Council, viz. : A. H. SEABROOK, S. J. WATSON, F. AYTON, T. ROLES, S. E. FEDDEN, W. WYLD, COUNCILLOR GIBSON, ALDERMAN SINCLAIR, ALDERMAN J. P. SMITH, and COUNCILLOR ELLAWAY. Of these Mr. SEABROOK, Mr. WATSON and Mr. AYTON to retire in 1915 ; Mr. ROLES and Mr. FEDDEN in 1916 ; COUNCILLOR GIBSON and ALDERMAN SINCLAIR in 1915 ; and ALDERMAN SMITH and COUNCILLOR ELLAWAY in 1916. If this resolution was carried it would carry out the views of the members and put them in order for future years.

Mr. H. Richardson seconded the resolution which was carried unanimously.

The President announced that no other nominations had been received for the following offices for the year 1914–15, and that Mr. H. RICHARDSON (Chief Electrical Engineer at Dundee) had been elected President for the year 1914–15.

MR. A. C. CRAMB (Chief Electrical Engineer, Croydon) was elected Senior Vice-President, and Mr. F. M. LONG (Chief Electrical Engineer, Norwich) was elected Junior Vice-President.

The Honorary Officers were elected as follows :—

Hon. Solicitor, Alderman C. Pearson (Bristol).
Hon. Secretary, H. Faraday Proctor (Bristol).
Hon. Treasurer, J. E. Edgcome (Kingston-on-Thames).

Before the voting took place for members of Council, there was some discussion as to the form of ballot paper.

Mr. F. Purse (Chief Electrical Engineer, Carlisle) called attention to the fact that at the bottom of the ballot paper it was stated that the number of names left in must " not exceed or be less " than the number required, otherwise the ballot sheet would be rendered void. He could not find in

the Articles of Association any authority for the use of these words. They prohibited, " plumping." Again, he understood that the ballot was secret, and yet the members had signed a paper at the entrance to the meeting-room which bore the same number as their ballot sheets.

The Hon. Solicitor said that if the Articles of Association had intended that there should be " plumping " it would have been specifically mentioned, but as it was not specifically mentioned, " plumping " could not take place. With regard to the secrecy of the ballot, the so-called secrecy of balloting in any election was provided for only to a certain extent. The secrecy of the ballot was preserved by sealing up in one envelope the counterfoils of the ballot sheets, and sealing up the ballot sheets themselves in another envelope. These were deposited with the clerk or person in charge of the ballot, and if a scrutiny was not demanded within a certain time, the papers were destroyed. This was what would be done in this case.

Mr. Purse dissented from the views of the Hon. Solicitor on the question of " plumping."

Alderman Foster (Portsmouth) said that if it was suggested that the procedure of an ordinary municipal or parliamentary election was being followed, then it should be followed in its entirety. In such an election a person was not bound to vote for members to fill every vacancy, and need only vote for two out of three if, as it might be, he was not in a position of knowing anything about a third member. Personally, he thought it would be very much better if the wording at the bottom of the ballot sheet had been omitted.

Mr. Purse said he would propose a resolution that all words after the words " not exceed " at the foot of the sheet be struck out.

The Hon. Solicitor pointed out that this could not be done so far as the present ballot was concerned. If the members desired to alter the ballot sheet in the future, however, that could be done later.

Alderman Bruce (Sunderland) asked whether it had been the practice of the Association to allow " plumping " in the past.

The Hon. Solicitor : No.

Alderman Bruce stated that it was parliamentary practice.

Mr. Purse asked on what authority it was now suggested that " plumping " should not be allowed. Was it merely a suggestion of the Council ?

The President said the arrangement of the ballot sheet was in accordance with the Articles of Association, and unless " plumping " was definitely arranged for it could not be allowed. The Articles were passed at the last Annual Meeting, and at a special meeting following, and they could not be departed from at this meeting. It was open to the Association to further alter the Articles if it were thought necessary.

Mr. Purse asked the Hon. Solicitor to say from his reading of the Articles, how " plumping " was prohibited. He had got the Articles and could not find that it said that a ballot sheet would be rendered void if the full number of names were not marked.

The Hon. Solicitor said it was no use discussing his opinion which he had already given.

The President said they must be bound by the Hon. Solicitor's opinion, and it was his opinion that they could not " plump " under the Articles.

Mr. Purse said he " plumped " at the last election.

The Hon. Solicitor said that in the happy-go-lucky style in which these elections were conducted previously, but which had worked exceedingly well although objections

were raised to it, there was nothing to prevent a man " plumping " and he could do it without asking leave one way or the other.

Alderman Foster said they must be governed by their legal advisor in this matter, but at a later stage he would move a resolution on the matter.

Mr. F. W. Purse (Carlisle) and Bailie Stevenson (Edinburgh) were nominated scrutineers for the ballot.

The following were the nominations for Members of Council :—

Engineers, three vacancies :—

W. A. Vignoles.	S. T. Allen.
J. H. Bowden.	J. K. Brydges.
J. W. Beauchamp.	C. S. Davidson.
E. E. Hoadley.	A. S. Blackman.
G. Pickvance.	H. Tomlinson-Lee.

The following were elected :—

W. A. Vignoles.	A. S. Blackman.
J. W. Beauchamp.	

Councillors, two vacancies :—

Councillor Crowther.	Alderman R. C. Davies.
Councillor W. B. Smith.	Alderman C. West.

The following were elected :—

Councillor Crowther.	Councillor W. B. Smith.

Incorporated Municipal Electrical Association.

NINETEENTH ANNUAL REPORT OF THE COUNCIL,

From June, 1913, to June, 1914.

(Adopted at the Annual General Meeting held at Birmingham, on Friday, June 19th, 1914.)

THE membership of the Association now stands at 380 made up as follows :—

Committees (Members)	167
Chief Electrical Engineers (Members)	174
Honorary Members	6
Chief Assistants (Associate Members)	4
Assistants (Associates)	29
	380

After allowing for deaths, resignations, removals, and lapses due to members leaving Municipal employ, there is a decrease of five on last year's total, chiefly among the Associates.

Since the publication of the last Annual Report, the Council have held nine meetings. At their first meeting they appointed the following Standing Committees, who subsequently elected their chairmen as stated.

INDUSTRIAL AND PARLIAMENTARY.—R. A. Chattock, A. C. Cramb, J. E. Edgcome, Alderman Pearson, H. Faraday Proctor (Chairman), H. Richardson, Alderman J. P. Smith, Councillor Ellaway, Alderman Bruce, S. E. Fedden, S. L. Pearce, A. H. Seabrook.

FINANCE AND GENERAL PURPOSES.—R. A. Chattock, J. Christie, A. C. Cramb, J. E. Edgcome, C. Furness, W. W. Lackie, Alderman Pearson, H. Faraday Proctor, H. Richardson, Thos. Roles, Alderman Sinclair, S. J. Watson, Alderman J. P. Smith (Chairman), W. Wyld.

EDITING.—R. A. Chattock, S. L. Pearce (Chairman), H. Richardson, S. J. Watson, G. Wilkinson, F. Ayton.

The Council meetings this session have been held in London with the exception of two held in Birmingham. There have also been a number of meetings of Standing and Special Committees and Sub-Committees appointed to deal with specific matters. These Committees have met and reported to the Council periodically on the matters referred to them.

By the courtesy of the Council of the Institution of Electrical Engineers, the Council and Committee meetings in London have been held at the Institution's headquarters.

The attendances of members of Council are set out in the following schedule :

	1913.				1914.						
	June, London.	July, London.	October, London.	November, London.	January, Birmingham.	February, London.	March, London.	April, London.	May, Birmingham.	Maximum possible.	Actual.
Ayton, F., Ipswich	×	×	×	×	×	×	×	×	×	9	9
Bruce, Alderman, Sunderland	×	×	×	×	—	×	×	×	—	9	7
Christie, J., Brighton	×	×	×	×	×	×	×	×	×	9	9
Cramb, A. C., Croydon	×	×	×	×	×	×	×	×	×	9	9
Chattock, R. A., Birmingham	×	×	×	×	×	×	×	×	×	9	9
Crowther, Councillor, Sheffield	×	Time expired.									
Edgcome, J. E., Kingston-upon-Thames	×	×	—	—	—	—	×	×	—	9	4
Ellaway, Councillor, Birmingham		—	×	×	×	×	—	—	×	8	5
Fedden, S. E., Sheffield		×	×	×	×	×	×	×	×	8	8
Furness, C., Blackpool	—	—	×	×	×	×	×	—	—	9	5
Gibson, Councillor, Wolverhampton	×	—	—	—	—	—	—	—	×	9	2
Lackie, W. W., Glasgow	×	—	—	×	—	×	—	×	—	9	4
Pearce, S. L., Manchester	—	—	×	—	×	—	×	—	×	9	4
Pearson, Alderman G., Bristol	×	—	×	×	×	—	×	—	—	9	5
Proctor, H. Faraday, Bristol	×	×	×	×	×	—	×	—	×	9	7
Richardson, H., Dundee	×	—	×	×	—	×	—	—	—	9	4
Roles, T., Bradford	×	×	—	×	—	—	—	×	×	9	5
Seabrook, A. H., London	×	×	×	×	×	×	×	×	—	9	8
Sinclair, Alderman, Swansea	×	—	×	×	—	—	×	—	—	9	4
Smith, Alderman, J P., Barrow	×	×	—	—	—	×	×	—	×	9	5
Wilkinson, G., Harrogate	×	-	—	×	×	×	—	×	×	9	6
Watson, S. J., Bury	×	×	×	—	×	×	—	×	×	9	7
Willock, Bailie, Glasgow	×	—	×	—	×	—	—	×	—	9	4
Wvld, W., Hampstead		×	×	×	×	×	×	×	—	8	7

Standardization of Metal Filament Electric Lamps.

In November last a meeting of the Engineering Standards Sub-Committee was held, which your representatives (Messrs. Fedden & Wilkinson) attended.

At the Council Meeting held during the morning of the same day, the question of rating metal filament lamps was fully discussed, and it was unanimously resolved that the standard rating of metal filament lamps should be in watts and not in candle power.

Your representatives on the Lamp Standards Committee of the Engineering Standards Committee urged the adoption of watt marking only. They found themselves in direct antagonism with representatives of the War Office, the Admiralty, the Post Office and Public Works, all of whom were tied down to vote under the direction of their respective departments though, as a matter of fact, they were personally in sympathy with the views of the I.M.E.A. A letter was subsequently sent to the Tungsten Lamp Association, informing them that the Standards Committee, by the majority of the votes from Government Officials on that Committee, had decided to adopt the standard of marking both the candle power and watts on lamps. The I.M.E.A. strongly objected to the same, and urged the Tungsten Association to still adhere to the resolution already adopted by them in regard to watt marking only.

The Tungsten Lamp Association in reply expressed their hearty approval in support of the marking of all lamps with watt rating only. The only exceptions made by members of the Association were where Government Departments made specific requests for candle power markings.

It is obvious from what took place, and from the views expressed by the representatives of Government Departments, that their interests in the matter do not harmonise with the interests of the public supply authorities, and thus matters have practically come to a deadlock so far as your Association and the Engineering Standards Committee are concerned.

Your Council and the lamp manufacturers are in agreement with regard to wattage rating, but it is not likely that a specification will be issued by the Standards Committee which will be acceptable to the Members of the Association unless the contemplated re-arrangement of the Standards Committee should result in considerable change in its constitution.

Report of the Electric Vehicle Committee.

In accordance with the resolution passed at the Annual General Meeting in 1913, the following have been appointed as a Special Committee to consider and adopt such measures as might be found desirable for furthering the use of the battery vehicle : The President (Mr. R. A. Chattock) ; The Hon. Secretary (Mr. Faraday Proctor), together with Mr. F. Ayton, Mr. J. Christie, Mr. A. C. Cramb, Mr. J. E. Edgcome and Mr. A. H. Seabrook. The Committee are empowered to co-opt representatives of other institutions, company-owned electric supply undertakings, manufacturers and others directly interested in this matter.

The first meeting of this Committee was held on the 5th September when your President was elected as Chairman and Mr. Ayton as the Hon. Secretary. A programme outlining the proposed scope of the Committee's work was decided upon, and in due course this programme was published in the various technical journals.

As a result of invitations issued by the Committee, the following have been made members to represent the various interests mentioned :

Representing Commercial Motor Users' Association, Incorporated—

E. S. SHRAPNELL-SMITH, Editor of " The Commercial Motor."

Representing Provincial Electric Supply Companies—

F. E. GRIPPER, Managing Director, Edmundson's Electricity Corporation, Ltd., London.

Representing Electrical Contractor's Association—

W. R. RAWLINGS, Rawlings Bros., Ltd., London.

Representing British Electrical and Allied Manufacturers' Association—

R. A. R. BOLTON, Siemens Bros. Dynamo Works Co., Ltd.
E. S. JACOB, Tudor Accumulator Co., Ltd.
W. S. NAYLOR, Chloride Electrical Storage Co., Ltd.
J. A. PHILLIPS, British Thomson-Houston Co., Ltd.

Representing Incorporated Association of Electric Power Companies—

J. S. HIGHFIELD, Chief Engineer, Metropolitan Electric Supply Co., London.

Representing Makers of Electric Vehicles—

CONWAY JENKINS, Fram Electric Vehicles.
K. BOWEN, Cedes Electric Traction, Ltd.
J. F. MONNOT, Arrol-Johnston, Ltd.
P. A. MOSSAY, Lloyd Electric Cars.
E. W. CURTIS, General Vehicle Co., New York.

Representing Edison Accumulators, Ltd., London—W. H. L. WATSON.

Mr. J. W. Beauchamp, a member of the I.M.E.A., has also been co-opted as a member of the Committee.

The Committee, through the membership of the Hon. Secretary, is affiliated with the Electric Vehicle Association of America. The Committee desires to place on record the very valuable assistance which they have received from the Executive Officers of that Association to whom they feel greatly indebted.

The work so far undertaken has covered the following :

Charging Plug and Receptacle.—After careful investigation, the Committee came to the conclusion that, for the present, at all events, the adoption of the 150 ampere concentric charging plug and receptacle, standardized by the Electric Vehicle Association of America, would meet all requirements. They have, therefore, submitted a recommendation to the British Engineering Standards Committee that this fitting should be standardized for use in the United Kingdom for the charging of electric vehicle batteries with the addition of means for earthing the chassis of the vehicle through the plug and receptacle and a third conductor in the flexible cable. They recommend that this earthing should be carried out in all cases, and suggest that the protection employed for the flexible cable should be similar to that known as "Cab-Tyre Sheathing." The Committee are considering the standardization also of a method of gripping this cable to the plug.

The Committee formed the opinion that it would be an advantage if some standardization could be arranged in connection with traction battery plates (lead cell), and accordingly placed a request before the accumulator makers section of the B.E.A.M.A. that that section should consider what could be done in the direction mentioned. The Committee is glad to place on record that, as a result, the B.E.A.M.A. has decided to recommend to the Engineering Standards Committee that plates should be standardized, viz., $8\frac{5}{8}'' \times 5\frac{3}{4}''$, with lug centres $4\frac{3}{8}''$.

The Committee has been able to make arrangements with the British Engineering Standards Committee to work on co-operative lines, and have placed before the Engineering Standards Committee recommendations as to parts which they suggest should be standardized for the United Kingdom.

The Committee also felt that it might be advantageous if important accessories connected with the electric battery vehicle, such as the charging plug and receptacle, battery trays and methods of fixing, charging voltages, etc., could be made International Standards. In this matter they have been fortunate in enlisting the services of the International Electrotechnical Commission which has agreed to undertake this work in co-operation with the Committee. In these matters of standardization, your Committee gladly acknowledge their indebtedness to Mr. Leslie S. Robertson, the Secretary of the British Engineering Standards Committee and Mr. C. Le Maistre, the General Secretary of the International Electrotechnical Commission.

Tariffs.—After making enquiries to ascertain the views of the various electric supply undertakings, both Company and Municipal, throughout the Kingdom, the Committee came to certain definite conclusions as to what might be recommended as suitable charges to be made by electric supply undertakings for the supply of electric energy for charging the batteries of electric vehicles. These recommendations were embodied in a circular letter which the Hon. Secretary sent to every electric supply undertaking in the United Kingdom. In very many cases, the supply authorities have intimated their willingness to come into line with these recommendations, which are as follows :

(1) That for charging which is carried out at times other than " peak load " hours, the rate should not exceed 1d. per unit at the supply authority's declared system and pressure.

(2) As to charging during " peak load " hours, the Committee consider that such, especially in the case of commercial vehicles, should seldom be necessary. In consequence of this, and the fact also that standing charges must, of necessity, vary greatly in different undertakings, they do not deem it desirable to make any recommendation as to a suitable tariff for such hours.

(3) The Committee suggest the wisdom of offering special encouragement to owners of vehicles to carry out charging operations between the hours of 11.0 p.m. and 6.0 a.m. by fixing a lower tariff for such hours. They consider that the supply, under such conditions, could be remuneratively given at a price of ¾d. per unit.

(4) The Committee recommend that a scale of discounts be arranged to meet the case of large consumers.

(5) It is also recommended that a special additional discount of 20 per cent. should be allowed off the rates mentioned in Paragraphs 1 and 3 above for all electric energy purchased for re-sale and metered on the consumer's premises. This would, of course, apply in the case of a public garage where the energy is purchased from the electric supply undertaking and sold to car owners bringing their vehicles to the garage to be charged.

(6) When the charging of vehicle batteries is carried out at a station under the control of the supply authority, the Committee consider it would be advisable to make a minimum charge for the supply of energy, and they suggest that such charge should not exceed 2s. for any one charging operation. It is further suggested that such minimum charge should only cover standing room or housing for the vehicle while the charging is being carried out, and that should the owner desire storage of the vehicle for any period after the completion of battery charging, it is open to the supply authority to make such further charges as it considers fit.

(7) The charges recommended under Paragraphs 1, 3, and 6 above, while they should, in the case of charging done at a supply authority's charging station, include connecting up and disconnecting, adjustment of current, etc., would not, of course, cover such items as " topping up " cells, inspection work, and the remedying of defects, all of which should properly be charged as extras.

Vehicle Insurance.—The Committee felt that it might help in the movement for popularizing the electric vehicle if prospective purchasers could be told that they could get vehicles insured at a lower rate than that in force for the petrol vehicle. They accordingly approached the various Insurance Companies and were eventually enabled to make arrangements whereby the Car and General Insurance Company of 1, Queen Victoria Street, intimated that they would give a 15 per cent. preference off their ordinary petrol insurance tariffs in favour of the electric battery vehicle, and probably later on increase the preference to 20 per cent. The Committee believe that it will be only a matter of time before other offices come into line in this matter.

Loans for the Purchase of Vehicles by Municipalities.—The Committee feel that it is very important that municipalities owning electric supply undertakings and who are, consequently, interested in the progress of the

electric vehicle movement, should use these vehicles for municipal purposes, especially in connection with the work of the Electricity Supply Department. They accordingly approached the Local Government Board with a request that the latter should, when asked, grant borrowing powers for the purchase of such vehicles. The Committee were glad to receive a reply from the Board, which reply has been duly published, stating that they are " prepared to entertain applications from Local Authorities for sanction to borrow money for the purchase of vehicles which they are authorised to provide in connection with the exercise of their statutory powers."

The Committee desire to place on record their indebtedness to the British Electrical and Allied Manufacturers' Association and various firms for the very ready and valuable assistance which has been given to the Committee in connection with the work of standardization and other matters.

Conditions for the Supply of Electrical Energy. —These conditions have been revised, and the new conditions, which constitute a model form, are included in another portion of these proceedings.

Exhibitions.—In conjunction with the British Electrical and Allied Manufacturers' Association much time has been devoted to the question of promoting Exhibitions in connection with the electrical industry, and amongst the applications that have been favourably considered are those of Bradford and Norwich.

Electric Lighting Bill.—The Council has spared no efforts to press forward this matter, and desires to acknowledge the work done and assistance rendered by Mr. Hugo Hirst and the late Mr. A. Bruce Anderson, Chairman of the B.E.A.M.A. A circular letter was sent to all members of the Association with regard to securing promises to ballot from the various members of Parliament, but no place was secured which could be of practical use.

A new clause for the exemption of fittings, etc., let on hire by contractors has been inserted, and the powers originally sought under Clause 1 (Powers to provide electrical fitting) has been amended, and the Bill in its present form has the support of the British Electrical and Allied Manufacturers, and it is believed of all other interested parties except the Electrical Contractors' Association.

The E.C.A. have declined to accept the proposed amendments, and have also signified their refusal to have the matter submitted to arbitration.

Subscriptions to Associations.—The question of the Payment of Subscriptions to Associations and of Delegates' Expenses has received considerable attention, and a clause authorising these payments is included in the draft I.M.E.A. Bill.

Model General Conditions of Tender. — The Council has had under consideration the standardization of conditions of Contract, joint meetings have been held with the Association of Municipal Corporations and the British Electrical and Allied Manufacturers' Association. The last meeting with the Association of Municipal Corporations was held on the 12th December last, since when no progress made by that body can be reported.

The I.M.E.A. representatives on the I.E.E. Model General Conditions Committee suggested that the I.E.E. should leave in abeyance their Final Proof pending agreement by other interested bodies. This suggestion was, however, not adopted, and the I.E.E. have issued their conditions without reference to either the I.M.E.A. or to the B.E.A.M.A. as being in agreement therewith.

Time for Tendering.—The question of time allowed for the preparation of tenders has been raised by the British Electrical and Allied Manufacturers' Association, and was considered by the Council, who are of opinion that the request of the B.E.A.M.A. that not less than three weeks

be allowed for the preparation of tenders for Turbine Plant is a reasonable one, and ask the members to act in accordance with this view whenever practicable ; and such request has been made public in the professional journals.

Gas Companies and Electricity.—A large number of Gas Companies in various parts of the Kingdom having promoted Bills containing Clauses authorising them to carry out the generation and distribution of electricity. Opposition has been brought to bear in several cases stating that the granting of the powers would operate most unfairly where the electrical undertaking is in the hands of the Local Authority, and resulting from such opposition promoters have withdrawn the clauses to which exception has been taken.

Industrial Committee.—The Institution of Electrical Engineers having disbanded the Industrial Committee, the Council have considered the desirability of the formation of an influential body representative of all sections and departments of the Electrical Industry, competent to deal with all matters of grave importance to the Electrical Industry. It was agreed that the proposal be approved in principle, and that preliminary arrangements be entered upon.

Local Government Board's Sanction for Loans.

The Council received a communication from the British Electric and Allied Manufacturers' Association, pointing out that cases had occurred where Local Authorities had requested contractors to accept contracts subject to the sanction of the Local Government Board being obtained to the necessary loan, and had requested the contractors to proceed with the work prior to the receipt of such sanction

The I.M.E.A. have agreed with the B.E.A.M.A. that such procedure imposes an unfair liability upon contractors, unless

the Local Authority in question undertakes to recompense the contractor for any "Work" so carried out at their request in the event of the contract not being entered into ultimately.

The Councils of the respective Associations have therefore agreed that their members should be advised to act in conformity with the foregoing arrangement. This has been communicated to, and published in, the *Electrical Press*.

Hon. Treasurer's Report.

The expenses for the year have been fairly normal, and the receipts from subscriptions exactly the same as last year.

The income from publications is a little less, and there is a surplus on the Convention account.

There is a surplus for the year of £65 and a total surplus of asset over liabilities of £786 of which sum £600 is invested in L.C.C. stock.

The Association has borne the preliminary expenses in connection with the Electric Vehicle Committee, amounting to about £12. It will, however, be impossible for the Association to indefinitely finance that Committee owing to the great increase in the scope of its operations and constitution, and some scheme will have to be devised whereby the Committee becomes self-supporting.

It will be noted that the Parliamentary expenses in connection with the Electric Lighting Bill have increased from £33 to £107, which sum is charged against the municipalities represented in the Association with a view to their paying their proportionate shares in due course.

Sundry debtors shew a marked decrease in outstanding subscriptions, the amount being less than the reserve for

INCORPORATED MUNICIPAL

INCOME and EXPENDITURE ACCOUNT

The Bold Figures are for the twelve

1913. £	s.	d.	EXPENDITURE.	£	s.	d.	1914. £	s.	d.
			To Bad Debts—						
37	2	0	Subscriptions written off ...	...		...	–	–	–
			„ General Expenses—						
12	0	0	Reporting and Clerical Assistance	19	0	0			
0	17	4	Bank Charges	0	11	0			
4	4	0	Audit Fee	4	4	0			
60	2	10	Sundry Expenses	63	7	5			
77	4	2					87	2	5
34	12	9	„ Postages			...	29	11	1
156	13	5	„ Printing and Stationery ...			...	174	2	9
150	0	0	„ Secretary's Salary			...	150	0	0
312	6	11	„ Convention Expenses ...			...	426	10	9
19	0	3	„ Commission			...	18	9	9
–	–	–	„ Electric Vehicle Committee Expenses			...	11	15	0
58	6	4	„ Surplus			...	65	7	8
£845	5	10					£962	19	5

BALANCE SHEET as

1913 £	s.	d.	LIABILITIES.	£	s.	d.	1914. £	s.	d.
25	14	0	To Subscriptions paid in advance		...	...	21	5	0
12	4	1	„ Sundry Creditors		...	...	9	3	3
			„ Surplus—						
662	14	5	Balance, April 1st, 1913	721	0	9			
58	6	4	Plus Surplus, for year 1913-14 ...	65	7	8			
721	0	9					786	8	5
£758	18	10					£816	16	8

Report of the Auditors, to the Members of the Incorporated Municipal
We have audited the above Balance Sheet, dated 31st March, 1914, and our opinion it is properly drawn up so as to exhibit a true and correct view of and the explanations given us, and as shown by the books of the Association.

140, Leadenhall Street, London, E.C., 15th April, 1914.

ELECTRICAL ASSOCIATION.

for the year ended 31st March, 1914.

months ended 31st March, 1914.

1913. £	s.	d.	INCOME.	£	s.	d.	£	1914. s.	d.
			By Annual Subscriptions—						
174	6	0	Committees	174	6	0			
185	17	0	Members	187	19	0			
5	5	0	Associate Members	4	4	0			
7	15	0	Associates	7	10	0			
373	3	0					373	19	0
17	6	2	„ Dividends and Interest				19	15	8
			„ "Proceedings"—						
116	13	2	Sales and Advertisements				106	5	0
338	3	6	„ Convention Receipts...				462	19	9
£845	5	10					£962	19	5

at 31st March, 1914.

1913. £	s.	d.	ASSETS.	£	s.	d.	£	1914. s.	d.
			By Sundry Debtors—						
1	1	0	Committees	–	–	–			
18	18	0	Members	6	6	0			
–	–	–	Associate Members	1	1	0			
1	5	0	Associates	1	10	0			
3	15	0	Sundry	4	0	0			
24	19	0		12	17	0			
15	0	0	Less Reserve for Bad Debts ..	6	7	0			
9	19	0					6	10	0
33	5	0	„ Parliamentary Expenses to be refunded ...				107	10	0
			„ Investment *at Cost*—						
599	5	0	£600 L.C.C. 3½ % Stock				599	5	0
			„ Cash—						
116	9	10	At Bank				103	11	8
£758	18	10					£816	16	8

Electrical Association.
have obtained all the information and explanations we have required. In the state of the Association's affairs, according to the best of our information

BOLTON, PITT & BREDEN, *Auditors.*
J. E. EDGCOME, *Hon. Treasurer.*

bad debts, consequently the small amount written off for bad debts is taken from the reserve and does not appear as an item of expenditure.

The balance sheet shews that the Association is in a sound financial position, though, owing to the nominal subscription chargeable to members, it has no funds available for other than current working expenses beyond the small reserve which has been gradually accumulated.

Engineers' Salaries.

At the Annual General Meeting last year Mr. Burnett of Barrow asked the Council to consider the question of the salaries paid to Central Station Engineers and their Assistants, with a view to bringing pressure to bear upon municipalities to improve the position both as regards salaries and the conditions of service.

Mr. Burnett subsequently supplied details in amplification of his proposals. The matter was carefully considered in all its bearings, and while in agreement with the suggestion in principle, the Council was unable to take further action in the direction indicated.

M.T.A. Conference, Sheffield.

The President, in conjunction with Mr. Fedden, Past President, attended the Municipal Tramways Association Conference at Sheffield last September as the official delegates of the I.M.E.A. They were very hospitably received and entertained.

Travelling Studentship.

There have been no entries for the Travelling Studentship during the past three years, and the Council's communications to the Associates regarding the reasons for the lack of interest in the matter, and inviting observations and suggestions, did not elicit any helpful response.

Standardization of Electrical Apparatus.

A Sub-Committee, consisting of Messrs. Cramb, Wilkinson, Fedden, and Seabrook, has been appointed to deal with the standardization of electrical accessories, including cooking appliances.

The Engineering Standards Committee have invited the appointment of two I.M.E.A. representatives on their Electrical Plant Accessories Sub-Committee. Mr. Cramb and Mr. Seabrook have been so appointed, Mr. Wilmshurst, your former representative, having resigned.

It is considered desirable that the I.M.E.A. should be represented upon all Sub-Committees of the Standards Committee on Electrical Engineering, and the Engineering Standards Committee have been approached upon this matter.

Yorkshire Electric Power Company's Bill.

The Council, having first ascertained that all Local Authorities affected by the above Bill were taking action, resolved as follows :—

> "Whereas the Association note with concern the attempt of the Yorkshire Electric Power Co., in its Bill, to appropriate all districts within its area which do not already form part of the area of supply of an authorized distributor; also in view of the fact that such powers would seriously interfere with the development of Municipal areas, and would in all probability entail a payment of compensation for goodwill in the event of an extension of Borough Boundaries or Municipal Lighting areas, the Council note with satisfaction that a petition is to be presented by the non-County Boroughs of Batley, Brighouse, Doncaster, Keighley, Morley, Ossett and Todmorden, and assures the various authorities of their moral support to the Petition."

A copy of the above resolution was forwarded in due course to each.

N.A.L.G.O. Delegate's Report.

The Council of the National Association of Local Government Officers held a very successful meeting at Bristol on March 14th last, when there were 90 representatives present from federated branches.

Several very important matters were discussed, but the one of most interest to the I.M.E.A. was that of Superannuation, for it will be remembered that it was more particularly in this connection that the Association became affiliated to the N.A.L.G.O. It was reported that a digest of the Superannuation Scheme had been prepared and circulated amongst the federated branches, and a number of these branches had complied with a request by approaching their Members of Parliament, with the result that over 200 Members had replied, and it is hoped that these replies will prove useful at the time of Parliamentary action. In the main, the replies were very favourable, and practically all supported the principle of superannuation, and a large majority consented to attend a meeting at the House of Commons, if the Association decided to convene one. It was further reported that the replies to hand were from 107 Unionists, 90 Liberals and 22 Labour Members, and a letter was to be sent to the Chancellor of the Exchequer asking him to receive a deputation from the Association, and if the deputation is received, and an opportunity presented itself, the question would be raised as to the possibility of the Chancellor obtaining a grant from the Government towards the cost of the scheme. The question of excluding workmen from the Provisions of the Bill was discussed at some length. Negotiations on this subject have been in progress with the Labour Party, and it was agreed to leave the final decision on the matter to the discretion of the General Purposes Committee. It is hoped that all members, both of the N.A.L.G.O. and the affiliated Associations, who have not yet approached their local Members of Parliament, will do so without delay, in order to obtain the utmost support to the Bill, and communicate the result to Mr. L. Hill, the

General Secretary of the N.A.L.G.O., Caxton Hall, Westminster, S.W.

The question of Parliamentary Representation was also discussed, and an amendment carried referring the matter back for further consideration of the General Purposes Committee, who had intimated that the time is not opportune for taking such steps, principally on the ground of expense.

The establishing of a Provident Section to commence with a deposit scheme for sickness benefit, and a scheme for death benefits, was also discussed, and the recommendation carried.

The I.M.E.A. Council is represented on the National Council of the N.A.L.G.O. by two Members, Mr. J. E. Edgcome, Past President, and Mr. Wyld. The latter was elected in place of Mr. George Wilkinson, Past President, who resigned owing to his inability to attend the meetings.

Mr. Edgcome was unable to attend the Bristol Meeting on March 14th through illness, but Mr. Wyld attended and reported thereon to the Council at a meeting held on March 20th last.

Electric Lighting Bill.

ARRANGEMENT OF CLAUSES.

Clause

1. Powers of undertakers to provide electrical fittings.
2. Power of companies to provide electrical fittings. Fittings to form part of companies' undertakings.
3. Showrooms and advertising.
4. By-products.
5. Supply of electricity to premises having separate supply.
6. Delegates' expenses.
7. Application of revenue.
8. Working capital.
9. Extension of Conspiracy and Protection of Property Act, 1875.
10. Entry upon premises; penalty for obstruction. Further powers as to entry upon premises.
11. Exemption of fittings, &c., let on hire by contractors from distress.
12. Power to lay cables, &c., in streets not dedicated to public use.
13. Joint exercise of powers.
14. Short title and construction.

A

BILL

TO

Give increased powers to Local Authorities with regard to Electric Lighting; and for other purposes connected therewith.

BE it enacted by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

Powers of Undertakers to Provide Electrical Fittings.

1.—(1) Any local authority authorised by Act of Parliament or Provisional Order to supply electricity (in this Act called "undertakers") may provide, sell, let for hire, and fix, repair, maintain, and remove, but shall not manufacture for the purpose of sale or letting on hire electric lines, fittings, apparatus, and appliances for lighting, heating, and motive power, and for all other purposes for which electrical energy can or may be used, in this Act called "fittings," and may provide all materials and work necessary or proper in that behalf, and with respect thereto may demand and take such remuneration or rents and charges and make such terms and conditions as may be agreed upon.

(2) Any undertakers may enter into and carry into effect contracts with any person for and in relation to the exercise of any of the powers conferred by this section.

(3) The exercise by any undertakers of the powers conferred upon them by this section shall be subject to the following restrictions:—

(*a*) The said powers shall be restricted to the undertakers area of supply, and to their consumers or prospective consumers.

(*b*) The undertakers shall so adjust the charges to be made by them for fittings, or for the fixing, repairing, maintaining, or removal thereof, as to meet in the aggregate any expenditure by them under the powers of this section in connection therewith (including interest upon moneys borrowed for those purposes and all sums applied to sinking fund for repayment of moneys so borrowed).

(*c*) Every sum charged by the undertakers to a consumer in respect of the provision of fittings, or the fixing, repairing, maintaining, or removal thereof shall be separately stated on every demand note delivered by the undertakers to the consumer, unless such sum is included in the price charged by the undertakers for the electricity.

(*d*) The total sums expended and received by the undertakers in connection with the purpose in this section mentioned in each year (including interest and sinking fund) shall be separately shown in the published accounts of the electricity undertaking of the undertakers for that year.

(4) With the view to securing co-operation between any undertakers exercising the powers conferred upon them by this section and persons carrying on the business of supplying fittings (in this Act called "Electrical Contractors"), the following provisions shall apply:—

(*a*) When the undertakers provide showrooms for the purpose of selling or letting fittings they shall, at the request of any electrical contractor whose shop or place of business is situate within the area of supply of such undertakers, give to him when practicable reasonable facilities for enabling his customers whose premises are situate in the said area to attend such showrooms and to inspect the fittings therein.

(*b*) Any electrical contractor who shall, at the request, whether expressed or implied, of any undertakers, sell any fittings on their behalf, shall, subject to any agreement which may be made between them, be entitled to receive out of the purchase money paid to the undertakers a sum calculated at the rate ordinarily allowed as discount in respect of such fittings by the makers thereof to electrical contractors, and based on the amount actually received by the undertakers in respect thereof.

(*c*) Any undertakers who pay a commission to the persons employed by them in respect of the sale or letting of fittings shall pay a commission at the same rate and under similar conditions to any electrical contractor upon whose introduction any fittings are sold or let by such undertakers.

(*d*) Undertakers shall not in the exercise of the powers of this section sell any fittings at a less price than the price (if any) which is determined and enforced by the makers of such fittings as the minimum price for the sale thereof to the class of customer to whom such fittings are sold.

(*e*) Undertakers shall not themselves execute the wiring of private property, except between the main of the undertakers and the consumer's meter, but they may enter into contracts for the execution of wiring under sub-section (2) of this section, provided that:—

(1) In making any such contracts for wiring undertakers shall not in cases where there are more than one electrical contractor whose shop or place of business is situate in their area of supply give any undue preference to any electrical contractors.

(2) No undertakers shall be subject to the restrictions contained in this paragraph in any case where there is not effective competition between the electrical contractors carrying on business in the area of supply of such undertakers in regard to the execution of contracts on behalf of the undertakers.

(*f*) Any question which may arise between any undertakers and any electrical contractor under this sub-section shall, unless otherwise agreed, be referred to an arbitrator appointed by the President of the Institution of Electrical Engineers, and the provisions of the Arbitration Act, 1889, shall apply to any such reference.

Power of Companies to Provide Electrical Fittings.

2.—(1) Any company authorised by Act of Parliament or Provisional Order to supply electricity may provide, sell, let for hire, and fix, repair, maintain, and remove electric lines, fittings, apparatus, or appliances for lighting, heating, and motive power, and for all other purposes for which electrical energy can or may be used, and may provide all materials and work necessary or proper in that behalf, and with respect thereto may demand and take such remuneration or rents and charges and make such terms and conditions as may be agreed upon: Provided that nothing

herein contained shall authorise a company to manufacture any such electric lines, fittings, apparatus, or appliances.

Fittings to Form Part of Companies' Undertakings.

(2) Any electric lines, fittings, apparatus, and appliances provided by or on behalf of any such company on consumers' premises, and any lands, buildings, or works held by them in connection therewith, shall be deemed to form part of the undertaking of such company authorised by the Act or Provisional Order in pursuance of which they supply electricity.

Nothing in this Act shall be deemed to restrict the exercise of any powers possessed by a company by virtue of its memorandum and articles of association or of any Act of Parliament.

Showrooms and Advertising

3.—Any undertakers may provide and maintain showrooms, promote and hold exhibitions, and exhibit electrical appliances, machinery, apparatus, or fittings, and may, by public advertisement or otherwise, publish and make known any matters connected with or affecting the sale of electricity, and may do all such other acts as they may deem expedient to assist, develop, or promote the use of electricity.

By-products

4.—Any undertakers may sell or otherwise dispose of any by-products incidental to the generation and distribution by them of electricity.

Supply of Electricity to Premises Having Separate Supply.

5.—Notwithstanding anything contained in the Electric Lighting Acts, 1882 to 1909, or any Act of Parliament or Provisional Order authorising an undertaking, the maximum electrical power with which any person shall be entitled to be supplied by any local authority, company, or person authorised by Act of Parliament or Provisional Order to supply electricity in any area shall not include any supply of energy taken only on extraordinary occasions, unless he has agreed with such local authority, company, or person to pay to them such minimum annual sum as will give them a reasonable return on the capital expenditure, and will cover other standing charges incurred by them in order to meet the possible maximum demand for those premises. The sum to be so paid shall be determined in default of agreement by arbitration.

Delegates' Expenses.

6.—The undertakers may, out of the revenue of their undertaking, pay reasonable subscriptions, whether annual or otherwise, to the funds of any association of local authorities, or of their officers, formed for the purpose of consultation as to their

common interests and the discussion of matters relating to the supply of electricity, and may purchase reports of the proceedings of any such conferences or meetings, and may pay any reasonable expenses of the attendance of any members or officers of the local authority, not exceeding in any case four, at conferences or meetings of the said associations or any of them.

Application of Revenue.

7.—In addition to the provisions contained in any Act of Parliament or Provisional Order relating to the application of the revenue received by any undertakers in respect of their undertaking, the undertakers may, if they think fit, instead of carrying the net surplus of such revenue remaining in any year and the annual proceeds of their reserve fund when amounting to the prescribed limit to the credit of the local rate, apply the whole or any portion thereof to any of the purposes of their undertaking, including the formation of a fund for working capital:

Provided that the fund so formed shall not at any time exceed a sum equivalent to one-half of the gross annual revenue of the undertaking for the time being.

Working Capital.

8.—(1) The undertakers may at any time borrow for the purposes of working capital in connection with their undertaking any sum or sums not exceeding in the whole one-tenth of the amount expended by them upon the purchase of lands and the construction of works for the purposes of the undertaking prior to the expiration of the period of three complete years after they shall have commenced to work the undertaking, or one-tenth of the amount which they shall have been authorised to borrow for the purposes of their undertaking prior to the expiration of that period, whichever amount shall be the larger.

1882-1903.

(2) The provisions contained in the Electric Lighting Acts relating to the borrowing of money by local authorities shall apply to the borrowing of money by the undertakers under this section as if they had obtained the consent referred to in section eight of the Electric Lighting Act, 1882: Provided that—

(*a*) Any money borrowed under this section shall be repaid within ten years from the date or dates of borrowing:

(*b*) It shall not be obligatory upon the undertakers to commence such repayment by means of a sinking fund or otherwise until the expiration of two years from the date or dates of borrowing.

Extension of Conspiracy and Protection of Property Act, 1875.

9.—From and after the passing of this Act the provisions of the Conspiracy and Protection of Property Act, 1875, shall apply as if the words "electrical energy" were inserted in section four (Breach of contract by persons employed in supply of gas or water) of that Act after the word "gas," wherever that word occurs, and as if the words "electricity works" were therein inserted after the word "gasworks."

Entry upon Premises; Penalty for Obstruction

10.—(1) Any person who shall hinder an officer appointed by any local authority, company, body, or person from entering any premises in pursuance of section twenty-four (Power to enter lands or premises for ascertaining quantities of electricity consumed or to remove fittings) of the Electric Lighting Act, 1882, or from exercising the powers contained in that section, shall be liable to a penalty not exceeding five pounds, and such penalty shall be recoverable in manner provided by the Summary Jurisdiction Acts.

Further Powers as to Entry upon Premises.

(2) Where any premises which any local authority, company, body, or person are entitled to enter in pursuance of section twenty-four of the Electric Lighting Act, 1882, are unoccupied, any local authority, company, body, or person may, after giving not less than forty-eight hours' notice to the owner thereof, or if he is unknown to such local authority, company, body, or person, by affixing such notice upon a conspicuous part of the premises, forcibly enter the same, doing no unnecessary damage.

Exemption of Fittings, etc., Let on Hire by Contractors, from Distress.

11.—(1) In this section the word "consumer" means any company, body, or person having an agreement with the undertakers for the supply of energy, and the word "contractor" means any company, body, or person who has by contract with the undertakers let, or agreed to let, on hire or disposed of, or agreed to dispose of, on terms of payment by instalments any apparatus and appliances to a consumer.

(2) All apparatus and appliances let on hire or disposed of on terms of payment by instalments by a contractor to a consumer, or which a contractor may have agreed to let on hire or dispose of as aforesaid, and being in or upon premises to which the undertakers have agreed to give a supply of energy shall at all times, subject to the terms of the contract between the contractor and the consumer, continue to be the property of the contractor, and be removable by the contractor or by the undertakers at the request of the contractor, and, subject as aforesaid, the power

to enter premises for the removal of fittings conferred upon the undertakers by section twenty-four of the Electric Lighting Act, 1882, and the provisions of section twenty-five of that Act and of section sixteen of the Electric Lighting Act, 1909, shall extend and apply to all such apparatus and appliances so long as they remain the property of the contractor, as if the same were apparatus and appliances let by the undertakers on hire or belonging to the undertakers within the meaning of such sections or any of them: Provided that the distinguishing metal plate or distinguishing brand or mark required by the said section sixteen to be affixed to or impressed or made on such apparatus and appliances sufficiently indicates that the contractor is the actual owner thereof, and that such apparatus and appliances are protected by virtue of this Act.

Power to Lay Cables, etc., in Streets not Dedicated to Public Use.

12.—Any undertakers may lay down, take up, alter, relay, repair, or renew in, across, or along, or out of any street, road, or path, laid out or made, but not dedicated to public use, within their area of supply, such pipes, cables, posts, and apparatus as may be requisite or proper for furnishing a supply of electricity within their area of supply, in the same way and to the same extent, and (so far as they are applicable) subject to the same provisions as to the breaking up of streets and the laying down of electric lines as if such street, road, or path had been dedicated to the public use.

Joint Exercise of Powers.

13.—The powers contained in sections one, two, and three of this Act may be exercised by any undertakers jointly with any other undertakers, or with any company, body, or person.

Short Title and Construction

14.—(1) This Act may be cited as the Electric Lighting Act, 1914.

(2) This Act and the Electric Lighting Acts, 1882 to 1909, shall be construed together as one Act, and may be cited as the Electric Lighting Acts, 1882 to 1914.

DRAFT OF THE I.M.E.A. FORM OF CONDITIONS FOR THE SUPPLY OF ELECTRICAL ENERGY.

CORPORATION OF .

Electric Supply Department.

The following "Conditions of Supply" have been drawn up by the I.M.E.A., and are intended to serve as a model only, being amended where necessary to suit local conditions. It is suggested that these conditions be attached to the application form to be signed by the intending consumers.

1. Method of Making Application for Supply.—Applications for supply must be made on the form provided, care being taken to fill in the details accurately. At least seven days' notice should be given of the date when the current is required, but the Corporation do not bind themselves to have a supply laid on within that period. Connections will be made in the order in which applications are received, or in which the premises are ready to take current.

2. Amount of Deposit.—The Corporation may demand a reasonable deposit or other security in respect of electricity supplied or of service lines laid by the Corporation. Interest will be paid at the rate of 4 per cent. per annum on the amount deposited for every six months during which the same remains in the hands of the Corporation.

3. Notice to Discontinue.—The consumer shall give at least twenty-four hours' notice, in writing, of his desire to be disconnected, and will be responsible for any electricity consumed on his premises until such notice has expired, notwithstanding that he may, in the meantime, have ceased to occupy such premises.

4. Length of Service Cable to be Supplied.—Distribution or service lines will be laid free of charge to the boundary of private property situated within feet of the Corporation's mains, and for a further distance not exceeding feet over private property (including private roads); for distances beyond this special terms must be arranged.

The service conductors will each terminate in a fuse supplied and fixed by the Corporation as near as practicable to the outer wall of the building.

5. Position of Meter, etc.—The Corporation will determine the position where the mains shall enter the premises, and also the position of the main cut-outs, meters, and their other apparatus, and no alteration or change must be made in their position except by the Corporation, and, if made at the request of the consumer, at his cost.

6. Interference with Corporation Apparatus.—Only the authorised officials of the Corporation are permitted to connect, disconnect or unseal the meters, indicators or main fuses, or interfere in any way with their service wires or meter leads.

7. Consumer Responsible for Damage.—The capacity of the Corporation service wires, fuses, meters, etc., will be so regulated as to carry permanently the maximum current required by the lamps or other appliances actually installed. Should the consumer at any time, without notice, connect any lamps or other appliances to the wiring which has already been tested and passed by the Corporation, damage may result to the apparatus of the Corporation, and the consumer will in that case be liable for the expense of making good the damage. The consumer is also required to take proper care of all apparatus of the Corporation fixed upon his premises, and is liable for the cost of making good any damage which may result through his not doing so. He is advised to include the apparatus in his fire insurance policy.

8. Notice re Extensions.—Additions or extensions to existing wiring must not be connected to the supply until they have been tested and approved by the Corporation, and notice, in writing, must be given at least forty-eight hours before current is required in the extensions.

9. Regulations for Wiring of Premises.—All internal conductors and other fittings shall be installed generally in accordance with the rules recommended by the Institution of Electrical Engineers and the rules of the Fire Insurance Office in which the premises are insured, and should also comply with the special regulations issued by the Corporation.

(Here insert local regulations.)

10. Consumer Responsible for all Installation Work.—The installation shall be installed by the consumer in conformity with the regulations issued by the Board of Trade and the Home Office so far as these apply, and shall be properly maintained by him unless arrangements are made to the contrary, and the Corporation shall not be held responsible for any work connected with the wiring inside the consumer's premises other than that done by their own workmen.

11. Value of Supply to be Determined by Meter.—The amount of electrical energy supplied to the consumer will be ascertained by suitable meters provided by the Corporation, which meters will have been previously tested and sealed. The Corporation will make no charge for the use of meters employed for the purpose of the account, but may make a charge for any meters supplied for the consumer's convenience. The reading of the meter or meters shall be taken as *prima facie* evidence of the energy consumed.

Alternatively: The amount of electrical energy supplied to the consumer will be ascertained by suitable meters

provided by the Corporation, which meters will have been previously tested and sealed. The following charges will be made :

Up to	amps. capacity	s.	d. per quarter.
Up to	amps. capacity	s.	d. per quarter.
Up to	amps. capacity	s.	d. per quarter.

The reading of the meter or meters will be taken as *prima facie* evidence of the energy consumed.

12. Re Testing Accuracy of Meter.—Should the consumer dispute his account he may, on giving forty-eight hours' notice to the Corporation, have the meter or indicator officially tested for a fee of s. d. ; and, if upon the necessary tests being made, the mean inaccuracy of the meter or indicator is found to be more than $2\frac{1}{2}$ per cent., the Corporation will pay the expense of such testing and will add to or deduct from the consumer's account, as may be required. Should the mean inaccuracy of the meter or indicator prove to be less than $2\frac{1}{2}$ per cent., the consumer shall bear all the expense of testing. In the event of a meter being found to register inaccurately, the consumer shall not be entitled to have an adjustment made for any account rendered prior to the complete quarter next before the date of his application to have the meter tested, except in the case of ampere-hour meters with a wrong declared voltage.

13. Installation out of Order.—If a consumer considers that for some reason his installation is out of order, or that there is a leakage of current, or a risk in its employment, he is recommended to turn off the supply at the main switch, and give notice at once to the Electric Supply Department at Telephone No. .
The Corporation are entitled to test an installation and to disconnect it without notice if they find it is not complying with their requirements.

14. Inspection.—The consumer must permit the various officials of the Corporation to visit his premises for the purpose of inspecting, altering or removing any of the property belonging to the Corporation, and also for inspecting his installation or any of the appliances connected thereto.

15. Improper Use of the Supply.—The Corporation is authorised to disconnect from the supply mains any installation where the current is so used or dealt with as to interfere with the satisfactory general distribution of the supply.

16. Accounts.—All accounts are payable weekly, monthly or quarterly, at the option of the Corporation, and in case of default in making payment, the Corporation may cut off the supply without notice.

Should a supply be given before a meter is fixed, or should the meter cease to register, the consumer will be required to pay for the energy consumed under such circumstances a sum based either on the former (or, subsequent, if no former) reading of the meter during days of approximately similar duration of lighting, or in the case of meters used for a power supply, *pro rata* with the actual amounts registered by the meter subsequently fixed.

Receipts for money are only given on the Department's printed forms, and no money should be paid to any person except in exchange for a receipt so given.

Local Clauses.

Price of Supply.
Motor Hire.
Payment of Accounts.

DISCUSSION ON THE ANNUAL REPORT

I.M.E.A. Bill.

Mr. E. E. Hoadley (Chief Electrical Engineer, Maidstone) asked as to the exact position of this Bill at the present moment, and what the Council advised should be done in the immediate future.

The Hon. Secretary said he regretted to say that the exact position of this Bill from the Parliamentary point of view, was very much the same as it was at the last Annual Convention. That was due to a great extent to the indifference shown by Members of Parliament, and the lack of interest taken by the members of the Association, or at any rate, by the corporations, in not getting their Members of Parliament to take a very active interest in the matter. It was common knowledge that the Association had circularised all the municipalities asking them to get their Members of Parliament to do what they could for the Bill and to ballot for a place. The ballot took place at the opening of each session of Parliament, and out of all the places represented in the Association, they had not been able to obtain more than two or three promises up to the date of the taking of the ballot. It was true that this year they received more than two or three; they received three or four, or perhaps six, but most of the promises came into his hands about two months after the ballot was passed! That illustrated the indifference of Members of Parliament, and if the members of the Association could not get their Members of Parliament to do something in the matter, it really made it an impossible task for the Association to get the Bill through on present lines. The Association had the sympathy and the active interest and support, he thought he could say, of everybody interested in this matter, with the exception of the Electrical Contractors' Association. They had the support of the technical Press, with the exception of *Electrical Industries*, which, of course, was more or less the organ of the electrical contractors directly or indirectly. They had the support of all the other technical papers, no matter what shade of politics they might hold themselves. They also had the support of the British Electrical and Allied Manufacturers' Association, who might very reasonably be expected to hold, at any rate, political views antagonistic to municipal trading. In other words, they had the hearty support and sympathy

of everybody except the electrical contractors. The President of the Board of Trade had not seen his way to grant an interview to a deputation yet. He did not know how much good it could do if he did grant such an interview. They were, however, intending to bring as much pressure as possible to bear to see if the Board of Trade could not give some active support. He was afraid that the only thing to do was to go ahead as they were doing. At the same time he doubted whether they had gained a very considerable amount of ground since last year, and thought that if a large number of local authorities would join together and promote a Bill for their own under takings, instead of relying entirely on the I.M.E.A. Bill, they would be successful in getting the powers they wanted. The difficulty was not in getting the Bill *through* the House but in getting it *before* the House. They had the support of Lord Ampthill, who had promised to give his active support in the House of Lords. Lord Ampthill had told him that he was sure the matter was misunderstood when it was before Parliament previously and now he (Mr. H. Faraday Proctor) really did not fear the House of Lords any more than he feared the House of Commons. He felt sure that they would get the Bill through both Houses if they could once get it before the Houses, and he thought that if those who were most keen on the matter could come together to divide the expense—perhaps a dozen or fifty, or even one hundred municipalities—there was no reason why they should not go jointly for a Bill to enable these particular municipalities to get the powers, and he thought they would get them. Any one particular municipality might be unable to bring sufficient pressure to bear, but if they went in a body they would. Then he believed the I.M.E.A. Bill would follow as a matter of course. He regretted that he could not give a more favourable report on this matter.

Mr. Hoadley asked if it were possible for a small or large number of municipalities to promote a Bill.

The Hon. Secretary said that this was just what he had suggested.

Mr. Hoadley asked if that would do any harm to the I.M.E.A. Bill in the future.

The Hon. Secretary said he thought it was the very best thing that could happen for the Association; the larger the

number the better. It was simply a matter of procedure, and anything of that sort would help the I.M.E.A. Bill eventually, and not weaken it in any sense or form.

Mr. W. C. P. Tapper (Chief Electrical Engineer, Stepney) asked if it would be possible to initiate the Bill in the House of Lords instead of in the House of Commons.

The Hon. Secretary replied that the Hon. Solicitor said practically speaking it would not be possible.

Mr. C. Turnbull (Chief Electrical Engineer, Tynemouth) asked if there was any precedent for a combined Bill of this sort.

The Hon. Solicitor said there were precedents among the gas companies, who had promoted Bills jointly for removing the restrictions upon the right to send sulphur fumes into houses and public streets, and they had been successful in getting these restrictions removed.

A Member asked that they might have some indication, by a show of hands, of the number of councils likely to take part in such a Bill.

Mr. C. F. McInnes (Chief Electrical Engineer, Gravesend) proposed that the Council should take steps to ascertain which municipalities would join in promoting a combined private Bill.

This was put to the meeting in the form of a resolution, seconded and carried.

Mr. R. H. Campion (Chief Electrical Engineer, Dewsbury) said that if this were done it would assist many authorities in the same position as his own. The Dewsbury Corporation were going for Parliamentary powers in an omnibus Bill, and were inserting these clauses. The Town Clerk had told him, however, that these clauses would be dropped if they were opposed, and therefore if a combined Bill could be promoted it would be of great assistance to him.

Mr. J. K. Brydges (Chief Electrical Engineer, Eastbourne) asked if the views of the Council of the I.M.E.A. were very divergent from those of the Institution of Electrical Engineers on this matter, because there had apparently been six months delay and nothing had been done.

The President said there had been considerable delay in handling this matter as he had explained in his Presidential address, and perhaps he had better ask the Hon. Secretary to explain the reasons.

The Hon. Secretary said it might be taken that the views of the Council were not very divergent from those of the Institution of Electrical Engineers ; indeed, it would be remembered that the I.M.E.A. Council was prepared to support the Model General Conditions of the Institution of Electrical Engineers about twelve months ago, but the general body of members did not see fit to agree with the Council at that time, and they resolved that the Association of Municipal Corporations should be consulted. They closed the door to any other procedure on the part of the Council by saying that it must not communicate with the B.E.A.M.A. or practically take any other steps until the Association of Municipal Corporations had put forward their decision on the matter and had reported it to a general meeting of the members. They approached the Association of Municipal Corporations immediately, but that body did not move so quickly as the I.M.E.A. ; perhaps the I.M.E.A. did not move too quickly, but the comparison still remained the same. He received from the Association of Municipal Associations only yesterday morning, a proof of the matter as they had amended it, but even now that had not been submitted to the Governing Council of that body, it had only been submitted to the Legal Council, and was the outcome of a joint meeting between some members of the Association of Municipal Corporations and some members of the I.M.E.A. Council. Insomuch, however, as the B.E.A.M.A. had not been consulted on any amendment put forward, he really did not suppose that it would help the matter very much, and probably it would be many years, or the whole matter would be almost dead, before there was active agreement upon what had been received from the Association of Municipal Corporations and the sellers

of the articles, viz., the B.E.A.M.A. There was another matter which he ought to mention. He had received a communication from the Secretary of the B.E.A.M.A. stating that their Council proposed to adopt the Model General Conditions as issued by the Institution of Electrical Engineers, for a period of one year in respect of municipal contracts in order to see how they worked. The B.E.A.M.A. had asked the views of the I.M.E.A. Council upon this proposal, and also asked if they would fall into line with it. This, however, had only just come to hand, and he had only been able to report the matter to the Council. They had not deliberated upon it because the members had already tied the hands of the Council, and the Council really could not very well move until the matter was settled by the Association of Municipal Corporations. Furthermore, it seemed to him that the general body of members had practically tied the hands of the Council, and he did not see that they could take any active steps until their hands were untied. They could only leave it as heretofore for each corporation to deal with the manufacturers as points arose.

Mr. R. H. Campion (Chief Electrical Engineer, Dewsbury) said with regard to the Parliamentary expense in connection with the I.M.E.A. Bill, that a good many of them had agreed to pay a proportion of the costs of this, but they had not heard anything of that yet. When would they be receiving an account ?

Mr. J. E. Edgcome (Hon. Treasurer) said that at the present time this expense was practically a suspense account. The Association had found the money, but they would call upon the members a little later on to pay their quota towards the expenses.

A Councillor Delegate, in moving the adoption of the balance sheet, complained that the report and balance sheet were not in the hands of members earlier, and also suggested that the attendance at the Annual Meeting suffered by reason of it being on the last day when many members desired to get home. He suggested that in future the annual meetings should be held on the first day of the conference.

The adoption of the Treasurer's balance sheet having been seconded and carried, the President explained that the Annual

Report had been printed at the commencement of the Convention week and was handed out with the other copies of the papers, so that it had been in the hands of the members for some days. He did not think it would be possible to get it out earlier. As regards the suggestion to have the Annual Meeting at the commencement of the Convention, this would hardly be possible in view of the fact that nominations for the election of Members of Council had to be received during the Convention and could only be considered on practically the last day.

Mr. W. C. P. Tapper said that only a limited number of copies of the Report were available on the first day, and those who were not present then could not obtain copies until the morning of the Annual Meeting.

The President said the question of having a sufficient supply of copies would be borne in mind next year.

Model Form of Conditions for Supply of Electrical Energy.

Mr. H. Bell (Chief Electrical Engineer, Hull) referred to the question of liability for fire to the supply authority's apparatus on consumer's premises. His attention had been directed to this matter by a serious fire recently in one of his consumer's premises, and he sent in a bill for the cost of the mains and apparatus. The Corporation had been advised, however, that, as there was no negligence on the part of the consumer, that they could not recover.

The President said that the conditions provided for the consumer being liable.

Mr. Bell said this could only be when negligence occurred, which was rather a difficult thing to prove.

The President said the matter should have the attention of the Council before the Conditions were issued.

Mr. A. G. Cooper (Chief Electrical Engineer, Colne) asked that consideration should be also given from the same point of view to apparatus on hire.

The President said this was usually covered by a special agreement.

Mr. Cooper said that this left it open for the fire insurance people to say that the apparatus was not covered unless fire was expressly put in the agreement.

The President said there was always a special agreement entered into with the consumer for hiring apparatus, and it should include a special provision as to protection from fire.

Mr. W. C. P. Tapper thought it would be very much better for each undertaking to take out a policy themselves to cover the whole of the apparatus. His Council had taken out a policy at Lloyds which covered any apparatus on hire or hire purchase, such as motors, meters, etc., also service lines, etc., and he did not worry the consumers with insurance of such apparatus. The system worked very well, and the premium was 2s. 6d. per cent. on the former, and 1s. 6d. on the latter.

Mr. H. S. Ellis (Chief Electrical Engineer, South Shields) thought it should be left entirely in the hands of the department to be responsible for their own apparatus. If this liability was put into an agreement, the consumers would kick at it. The consumer did not like to be told he *must* do things, and it was desirable that it should be left out of it altogether.

The President said the matter should have the attention of the Council.

Adoption of Annual Report.

The Annual Report was then put to the meeting by the President, seconded by Mr. H. Richardson, and carried unanimously.

Election of Auditors.

The Auditors of the Association, Messrs. Bolton, Pitt & Breden, were re-elected.

Place of Meeting for 1915.

Mr. H. Richardson (President Elect), with regard to this matter, said that his Convener and Chairman was present, and it would be more fit for him to express the views of the Dundee Electricity Committee on this matter. As far as he was personally concerned, he would be pleased to go where the majority of the members would like to go, and would suggest that it might be left to the Council for final decision.

Bailie Nairn (Convener of the Dundee Electricity Committee) said he was sure the Dundee Corporation would highly appreciate the honour which had been done to their Electrical Engineer in electing him President of the Association for next year, and if the Association thought of going to Dundee for the meeting, they would receive a very hearty welcome indeed.

It was decided to leave the matter in the hands of the Council.

Disaster to the "Empress of Ireland."

The President said there was one matter he would like to bring to the notice of the members in connection with the recent disaster to the "Empress of Ireland." A very old friend of many of them went down on that boat, and he would very much appreciate it if at the meeting they would pass a vote of sympathy and condolence with the widow, and with the B.E.A.M.A. in the loss of their Chairman.

The resolution in the following terms was passed by the members standing:

> "The members of the I.M.E.A. in the Annual Meeting assembled, are desirous of expressing to the widow and family of the late A. Bruce Anderson, Esq., their sincere sympathy and regret at the deplorable loss sustained owing to his death in connection with the foundering of the "Empress of Ireland"; also to sympathise with the B.E.A.M.A. in the loss of such an energetic and valuable Chairman."

Form of Ballot Paper.

Alderman Foster (Portsmouth), reverting to the previous discussion as to the form of ballot paper, moved that the words at the bottom of the ballot paper should read, "not exceeding

the number to be elected," and that the words, " or to be less than," should be omitted. The object of this, he said, was to enable a member to vote for one, two or three of the proposed candidates, as he might think fit, and not that he must necessarily vote for all three or the full number which had to be balloted for.

Mr. H. S. Ellis (Chief Electrical Engineer, South Shields) seconded.

Mr. C. L. E. Stewart (Chief Electrical Engineer, Rawtenstall) asked if the Council had any special thing in mind in putting these words in. The Manchester Local Section of the Institution of Electrical Engineers had had to put them in for the special reason that there were one or two large firms in Manchester, and it had been found by " plumping " it was possible to have on the Council representatives only of one or two of the large firms, and that an outsider had no possible chance of getting on the Council. Had there been anything special of this sort in the minds of the Council in barring " plumping " ? The Institution had a very good reason for it.

Alderman J. S. Smith (Barrow-in-Furness) moved an amendment to the resolution that the ballot paper be continued in its present form.

Mr. H. Richardson (Chief Electrical Engineer, Dundee) seconded.

The Hon. Solicitor said this was not a matter of vital importance one way or the other ; the procedure was exactly the same as that of the Institution of Electrical Engineers.

Mr. W. W. Lackie (Chief Electrical Engineer, Glasgow) said he remembered quite distinctly that in 1901 it was clearly shown that the Council could be made to consist of men in and around London if " plumping " were allowed.

Mr. H. Richardson said that what they really wanted was the real opinions of those present as a whole. He believed that the ballot paper as it stood reflected the feelings of the Convention.

Mr. F. W. Purse (Chief Electrical Engineer, Carlisle) said he should be sorry if the I.M.E.A. followed the Institution of Electrical Engineers as it was now going. He hoped it would not. The Institution of Electrical Engineers were expected to show some initiative, and they should do so. They should follow their own ideas in the matter, and, therefore, he would like to see the resolution voted upon.

The Hon. Secretary said that it might be remembered that six years ago he was put upon the Council of the Institution of Electrical Engineers, and he might say that one of the tasks which was set for him was to get the Articles of Association of the Institution of Electrical Engineers altered. He was on that particular committee which dealt with this matter, and the present Articles of the Institution were the outcome of their deliberations. He could practically say that he got his own way on this particular matter, although it was the desire of many others also, and, having got his own way there, he endeavoured to get his own way on this occasion, and he really did not see why the example of the Institution should not be followed. Mr. Purse had criticised the Institution of Electrical Engineers, and he did not pretend to disagree with him, but this was not the most suitable time for discussing that matter. He believed that the Institution of Electrical Engineers, as the result of the alteration of their Articles of Association, had got many more provincial members on to the Council recently, and the general body of the Institution was better pleased with the procedure in that respect, and he believed the general body of the I.M.E.A. would be better pleased with the results of this action in the future.

Alderman Foster's resolution was then put to the meeting and was declared lost by a large majority.

A Special Committee for Developing Electricity Supply.

Mr. W. A. Vignoles (Chief Electrical Engineer, Grimsby) moved the following resolution :

> " That a Special Committee be formed of members of this Association, not necessarily members of Council, to deal with any matters that may tend to encourage the use of electricity from the public supply mains, and that this Association shall invite other associations and persons who can assist in furthering the object for which the Committee is formed, to join such Committee."

Continuing, Mr. Vignoles explained that this resolution was the outcome of the suggestion made in his paper. He was now proposing that one committee should be formed instead of two, which should have a rather broader outlook, with power to co-operate or invite other associations who were interested, such as manufacturers, etc. It had been suggested by some members that a committee should be formed to replace the defunct Industrial Committee of the Institution of Electrical Engineers, but that, he thought, would be too large a task for the Association to tackle, and he was of the opinion that they should stick to the one point that he had suggested, viz., to further the supply of electricity from public supply mains, which was the main object for which the Association was formed. Previous efforts in the direction of furthering the industrial interests of the electrical industry, had not been very successful. An association was formed some time ago called the " Association for the Protection of Electrical Interests," which met a few times, but it did not seem to find anything to protect and had finally abdicated. Later on the Industrial Committee of the Institution of Electrical Engineers, as they had heard, was formed and met on a number of occasions, but that finally committed suicide ; but he hoped that the Committee which he had now suggested would not follow either of the courses which its predecessors had taken. He believed that the reason for what had happened in the past was that the Committees had not been promoted by the right people, or they did not get the right members on the Committee, or that there were clashing interests. In this case, however, the one interest of everybody was the promotion of the supply of electricity from public supply mains, and they should keep that one object in view and keep their eyes firmly fixed upon it. As far as the appointment of the Committee was concerned, that would be best left to the Council, and he had no feelings in the matter. All he hoped was that they would get the right men on the Committee ; they wanted people who had plenty of energy and a nose for the business side of electricity.

Mr. T. Roles (Chief Electrical Engineer, Bradford) seconded the resolution, and said that in view of the activities of the British Commercial Gas Association, it was necessary for the I.M.E.A. to take some such step as had been suggested by Mr. Vignoles to develop the use of electricity generally in this country. It was a very large subject to tackle, and it would need men who were prepared to devote a lot of time to the work. He was very pleased to see that Mr. Vignoles had himself, now been

elected a member of the Council, and in these circumstances there was little doubt that the Council would desire that Mr. Vignoles should be one of the members of the proposed Committee. There were, however, other members of the Association and also outsiders who had taken an interest in some special subject, either publicity, or in connection with heating and cooking, or motive power, and the suggestion that the Committee should have powers to co-opt such persons was a very good one. He presumed that it was intended to run this Committee on somewhat similar lines to the Electric Vehicle Committee, which had been most successful, considering that it had only been appointed since the last Convention. Its success was remarkable in his opinion, and there was little doubt that it had been largely obtained, because one man had put his shoulder to the wheel and had pushed the whole thing along. He thought he might be allowed to mention what Mr. Ayton had done for this Committee, and he hoped they would find gentlemen who would take similar interest in the Committee which Mr. Vignoles had proposed should be formed.

Alderman J. P. Smith (Barrow-in-Furness) said that while in general sympathy with the object of the resolution, he had his doubts as to whether this was the best way to go about it. He had been struck very frequently at the annual meetings with the amount of talking they did round a subject without getting at it, and he believed the reason was that they took too wide a scope. That had been exemplified in the papers this year, which were of too general a character and about which anybody could talk platitudes, and when it was all over they were not very much nearer. With regard to the Committee, would it not be very much wiser to take some particular subject and appoint a Committee to go into that. Reference had been made to the Electric Vehicle Committee, which had undoubtedly made an excellent start, and he believed it was really going to get something done. The Committee now suggested seemed to him to be of too wide a character. Publicity itself was a very big subject and required very special handling, and he would like to put forward a suggestion which he had heard made by others, that a Committee, for instance, to deal with the question of cooking should be first appointed, and that round table conferences should be held with the manufacturers. In this way he believed that more progress would be made by taking one subject at a time than by appointing a Committee to deal with

the whole question. When he heard this suggestion, he regarded it as a very good one, and there were other subjects which might be tackled in the same way afterwards.

Mr. F. Ayton (Chief Electrical Engineer, Ipswich) remarked, that having seen the excellent results which could come from co-operative effort as exemplified by the work of the Electric Vehicle Committee, he wished to entirely support the proposal made by Mr. Vignoles. With regard to Alderman Smith's remarks, he had had a good deal of conversation with Mr. Vignoles on this matter, and it was quite open to the new Committee, when it really got to work, to decide what subjects should be delegated to the Sub-Committees. Even the Electric Vehicle Committee had appointed Sub-Committees, and the new Committee proposed would have to work on similar lines. It was, however, impossible at the present time to define exactly the lines on which the Committee should work. What they had in mind was the greater development of electric supply. They were all alive to the very powerful interests which were at work by the gas companies, and the only answer to the onslaughts of the British Commercial Gas Association was increased activity, more unremitting propagandism, and increased aggressiveness. That could only be brought about by concerted action with the manufacturers, who were just as interested as central station engineers in bringing this about. Even if the new Committee did not get the support of the other interests in the electrical industry—but he believed it would—central station engineers would have the satisfaction of feeling that they had done their share to bring about a greater degree of prosperity in the future.

Mr. J. E. Edgcome (Chief Electrical Engineer, Kingston-upon-Thames) said that in whatever manner the Committee was formed he would like to heartily support it. With regard to the question raised by Alderman Smith, that the Sub-Committees should be specialised for particular subjects, he might refer to the good work done by the Diesel Engine Users' Association which was formed last year, and which met monthly with a view to discussing little troubles arising from the use of Diesel engines. This Association had a very wide membership, and included not only central station engineers, but engineers of companies who were users of Diesel engines. The system adopted was to invite a manufacturer of a particular piece of apparatus used with Diesel engines, to attend a particular meeting, and to discuss troubles

arising with this apparatus. For instance, one meeting had been devoted to a discussion upon compressors. Messrs. Reavell, who made these for a large number of different makes of Diesel engine, sent one of their representatives who gave very valuable information to the users and who, no doubt, in turn derived very useful results from the experience and troubles of the engineers. By specialising in this way a great deal of good would be done and co-operation brought about with the manufacturers.

A Councillor Delegate expressed the opinion that a good deal of the troubles of the industry in this connection were due to the indifference and apathy of the members of Councils, and anything which could be done to create a more active interest in this aspect of electric supply would be of the greatest possible advantage. The work of the Committee should tend to help the engineers in this respect, and he supported the proposal.

Mr. W. H. Cooke (Chief Electrical Engineer, Luton) supported Mr. Vignoles' resolution, and thought it would be a great mistake to limit the scope of the Committee as suggested by Alderman Smith, because he had found in developing one source of supply a large number of other possible sources were discovered. Reference had been made to specialising in electric cooking, but there was already an Association looking after that, whilst there was also the Electric Vehicle Committee, and both of these would no doubt be of the greatest possible assistance to the new Committee in developing these particular branches.

Mr. A. H. Seabrook (Chief Electrical Engineer, Marylebone) said he did not think it was worth while discussing details of this kind. The great point was to support Mr. Vignoles; and surely when the Committee was constituted, it would be time to discuss its policy. No doubt it would find ways to sectionalise itself to deal with the various subjects.

The President then put the resolution to the meeting, and it was carried unanimously.

Votes of Thanks.

On the motion of the President, a hearty vote of thanks was accorded to the Mayors and Councils of the various towns which had entertained the members during the Convention, and also

to the manufacturers who had thrown open their works for inspection. Included in the resolution also were the Chairman of the Coventry Electric Lighting Committee and Mr. G. Tough, the Coventry Electrical Engineer, in addition to Mr. H. Foulds, Secretary to the Birmingham Corporation Electricity Department, who had so ably organized the local social functions on behalf of the Entertainment Committee.

Alderman Foster (Portsmouth) proposed, and Mr. A. S. Blackman seconded, a hearty vote of thanks to the President and Mrs. Chattock for the hospitality which they had shown to the members during the Convention.

Votes of thanks to the Hononary Officers brought the proceedings to a close.

Nineteenth Annual Convention, Birmingham, June 15th to 20th, 1914.

SUMMARY OF PROCEEDINGS.

The headquarters of the Association was the Grand Hotel, Birmingham, where a Bureau was established for registering attendances and transacting the organization work in connection with the issue of tickets, etc. 200 engineer members, 60 Committee representatives, and 160 visitors registered their names. More than 80 ladies also attended.

The proceedings commenced on the Monday evening with an informal reception and Smoking Concert at the Grosvenor Room at headquarters, given by the Birmingham Entertainments Committee. A first-rate programme was provided under the direction of Mr. George Russell, the other artistes being Miss Clara Winwood, Miss Dorrie Dene, Mr. Orton, Mr. Bert Gregory, Mr. Bertram Evans, Mr. Willett Raine, and Mr. Willis Crisford.

The printed souvenir and programme contained a very excellent likeness of the President of the Association, Mr. R. A. Chattock, City Electrical Engineer and Manager.

Mrs. Chattock and a number of other ladies were present.

The official proceedings opened at the Midland Institute on Tuesday morning, when the Rt. Hon. the Lord Mayor, Lieut. Col. Ernest Martineau, welcomed the Association. The President then read his inaugural address, and was followed by Mr. W. A. Vignoles, Chief Electrical Engineer of the Corporation of Grimsby, with a Paper on "The Commercial Development of Electrical Supply in Towns of Moderate Size."

The Members, Delegates and Visitors were afterwards entertained to luncheon at the Grosvenor Room of the Grand Hotel by the Birmingham Entertainments Committee.

The pleasure of the party was much enhanced by the very entertaining and apposite speeches of Bailie Willock (member of the I.M.E.A. Council), and Alderman Bowater, the Deputy Lord Mayor of Birmingham and Chairman of the Finance Committee in respectively proposing and responding to the toast of "The City of Birmingham."

During the luncheon a programme of music was performed by Herr Henrich Sücks' orchestra.

In the afternoon the Members and Delegates visited the works of the General Electric Co., at Witton, and afterwards saw a demonstration of Electric Battery Vehicles, organized by the Electric Vehicle Committee of the I.M.E.A., under the direction of Mr. Frank Ayton, the Hon. Secretary of that Committee. Subsequently the party visited the works of Messrs. Belliss and Morcom.

During the afternoon the ladies visited the New Street Picture House, and were afterwards entertained to tea by Mrs. Chattock at the Wedgwood Tea Rooms. The visit to the Art Gallery had to be abandoned, it being closed following damage by a Suffragette.

The Annual Dinner was held in the evening at the Grosvenor Room, Grand Hotel, when the President, Mr. Chattock, who was accompanied by Mrs. Chattock, presided over a gathering of about 400 members and visitors, including a number of ladies.

The guests of the evening were the Lord Mayor of Birmingham and the Lady Mayoress (Lt. Col. and Mrs. Ernest Martineau), the Deputy Lord Mayor (Alderman Bowater), the Mayor of Stratford-upon-Avon (Councillor Winter, J.P.), Mr. A. Home Morton, Dr. Ferranti (Past President I.E.E.), Mr. (now Sir) John F. C. Snell (Past President of the I.M.E.A.), President-Elect I.E.E., Mr. Alfred Baker (Manager Birmingham Corporation Tramways), and Councillor Lee, Chairman of the Electricity Committee of the City of Coventry.

After the loyal toasts had been duly honoured, the toast of "The City of Birmingham" was proposed by Alderman Bruce, Chairman of the Electricity Committee of the Corporation of Sunderland (Member of Council), and responded to by the Lord Mayor.

Dr. Ferranti proposed the toast of the I.M.E.A., to which the Chairman replied. Mr. J. F. C. Snell, President-Elect of the I.E.E., proposed "The Electric Supply Committee of Birmingham," to which the Chairman of that Committee, Councillor Ellaway (Member of Council, responded.

Mr. H. Richardson, Senior Vice-President, proposed "The Guests," and to which the Mayor of Stratford-upon-Avon and Councillor Lee of Coventry responded.

The Musical Programme was under the direction of Mr. G. A. Russell, the other artistes being Miss Gertrude Fuller, Miss Olive Pank and Mr. Arthur Jordan. During the Dinner a programme of instrumental music was provided by Herr Sücks' orchestra.

The party left Birmingham on Wednesday morning by special train for Coventry, where they were welcomed at the Guildhall by His Worship the Mayor, Councillor S. Bettmann, J.P.

After his courtesy had been duly acknowledged by the President, a Paper on "The Design and Operation of Modern Boiler House Plant," by Mr. S. E. Fedden, Past President, Chief Electrical Engineer of the Corporation of Sheffield, was read and discussed.

Subsequently the party was entertained to luncheon at the Drill Hall by the Mayor, who also kindly provided a printed souvenir of the visit in the form of an illustrated guide to the City.

During the morning the ladies visited Coombe Abbey, by kind permission of the Rt. Hon. the Earl Craven, Lord Lieutenant of the County of Warwickshire. In the afternoon they were conducted to places of interest in the City under the guidance of Members of the Corporation and other gentlemen, while the members inspected the chief engineering works in the City, or paid a flying visit to those of the British Thompson-Houston Co. and of Messrs. Willans & Robinson, at Rugby.

The party returned to Birmingham in time for the Reception and Dance at the Council House, given by the Lord Mayor and Lady Mayoress.

Here a new duty was imposed upon the Secretary, who had to vouch for every member of the party before they could pass the police cordon placed there to prevent the admission of Suffragettes. A very excellent musical entertainment was provided, and those who preferred dancing were catered for in a way that left nothing to be desired.

The next morning (Thursday) saw a fleet of motor vehicles drawn up at headquarters to convey some 400 passengers to Stratford-upon-Avon. After a pleasant drive over historic ground and through beautiful scenery, the party reached the Memorial Lecture Room, where the Mayor (Councillor F. Winter, J.P.) gave them a hearty welcome.

The ladies were conducted to places of interest under the guidance of members and officials of the Corporation, while the members took part in a discussion on a Paper on "The Standardization of Tariffs," by Mr. J. H. Bowden, Chief Electrical Engineer of the Corporation of Poplar.

Luncheon was served at the Town Hall, and at 2.30 p.m. the party proceeded to Warwick, where they assembled in the Castle Grounds and were photographed. Afterwards some inspected the Castle, and others strolled through the beautiful grounds. The run home was made via Kenilworth, passing the Castle ruins en route, and Birmingham was reached about 6.30 p.m.

In the evening there was an Open-Air Fete and Concert at the Botanical Gardens, given by the Birmingham Entertainments Committee. The Members were received by the President and Mrs. Chattock, and there was a vocal and instrumental Concert by Miss Marie Rowe and Mr. Stoddart, and the Band of the 5th and 6th Battalions of the Royal Warwickshire Regiment (by kind permission of Lt.-Col. E. Martineau, V.D., Lt.-Col. H. I. Parkes, V.D., and Officers).

The entertainment ended with a Firework Display, the set piece being a message of welcome, which fittingly developed later into a portrait of the President, Mr. R. A. Chattock.

The whole entertainment was by general consent voted one of the most successful ever provided on such an occasion.

The Annual General Meeting took place on Friday morning at the Midland Institute. The new system of balloting for the Officers and Council worked successfully, and survived some criticism on the numbering of the ballot sheets. All the business on the Agenda having been disposed of, the meeting terminated with votes of thanks to all who had been concerned in making the Convention so great a success.

The afternoon was occupied in a visit to the Corporation Electric Generating Station at Summer Lane, and in the evening a most successful Cinderella Dance was held at the Grosvenor Room, Grand Hotel, organized and given to the Convention by the Birmingham Entertainments Committee.

By Saturday morning the greater number of the members and delegates had dispersed, but quite a large party mustered at 8.40 a.m. at New Street Station for Worcester. On arrival the party was met at the station by Mr. C. M. Shaw, the City Electrical Engineer, and by the High Sheriff, Mr. Arthur Carlton, and proceeded to the Guildhall, where they received a very hearty and hospitable welcome from His Worship the Mayor, Alderman A. H. Leicester.

Visits were then paid to various places of interest in the City, under the guidance of members of Mr. Shaw's staff, and at 11.30 a.m. a start was made in motor vehicles for the Water Power Station at Powick. Here there was much to interest all concerned, for while the engineers were inspecting the low-pressure turbine, the ladies were criticising the electric laundry adjoining, afterwards resting in Mrs. Shaw's charming garden close at hand.

In due course the party proceeded for a drive round the Malvern Hills, and Worcester was reached at 2.30 p.m., the party by that time being quite ready for luncheon, which was served at the Hop Market and at the Star Hotels.

After due acknowledgment by the Chairman of the services of Mr. Shaw in making the local arrangements, the party returned to Birmingham, which was reached at 5 p.m. There the party separated, with the feeling that the Convention, if one of the most strenuous, had been also one of the most successful.

Mention should be made of the fact that Messrs. Chamberlain & Hookham, Veritys, Ltd., Simplex Conduits, Ltd., Tubes, Ltd.,, W. & T. Avery, Ltd., and J. H. Tucker & Co., of Birmingham, most kindly offered to show parties over their works during the Convention, and that their courtesy was none the less appreciated in cases where it was found impossible to take advantage of it, owing to the already overcrowded programme.

The weather was perfect during the whole of the week, and, thanks to the co-operation of all taking part in the organization, the entire programme was carried through without a hitch.

The Association is greatly indebted to all who so generously entertained the Convention, whether Chief Magistrates of the cities and towns visited, Directors of Engineering Works, or Entertainment Committees. All vied with each other in extending a hearty and hospitable welcome to the visitors, and all succeeded in giving the greatest pleasure to those whose good fortune it was to participate in their hospitality.

The organization involved in drawing up and carrying through the official programme, was very considerable prior to, during, and subsequent to the Convention week. In connection with the local arrangements, the Association were fortunate in securing the co-operation of Mr. Howard Foulds, the Secretary of the Birmingham Electric Supply Department, who placed his long experience and local knowledge freely at the disposal of the Association, and who was entirely responsible for the whole of the social functions organized so successfully under his direction by the Birmingham Entertainments Committee.

MEMBERS, DELEGATES AND VISITORS ATTENDING THE BIRMINGHAM CONVENTION.

[The abbreviation *Ch'n* stands for Chairman of the Electricity Committee, *C'r* for member of Electricity Committee, *E.E.* for Chief Electrical Engineer.]

The following is a list of the members, delegates and visitors who intimated their intention of attending the Convention:

R. L. Acland (*E.E.*, Chesterfield); P. R. Allen (Castner-Kellner Alkali Co.); S. T. Allen (*E.E.*, Wolverhampton); H. W. Angus (*E.E.*, Eccles); A. W. Annetts (*E.E.*, Morecambe); F. J. W. Ashlin (*Resident Engineer*, Water Street, Birmingham); J. Ashworth (*Ch'n*, Heywood); C. C. Atchison (*E.E.*, Rochdale); A. Atkinson (Clarke, Chapman & Co.); F. Ayton (*E.E.*, Ipswich); R. Ayton (*E.E.*, Winchester); W. J. Bache (*E.E.*, Cheltenham); T. H. Bacon (*Ch'n*, Hammersmith); W. J. Bailes (*Ch'n L'tg Sub-Com*, Liverpool); R. U. Bailey (*Resident Engineer*, Summer Lane, Birmingham); Ald. G. Ball (Stockport); Ald. Banton (*Vice-Ch'n*, Leicester); C. Barber, London; A. W. Barham (*E.E.*, Watford); E. A. Barker (*E.E.*, Barnsley); A. S. Barnard (*E.E.*, Walsall); Jas. Bastian (Bastian Meter Co.); J. S. Bates (*Cr.*, Coventry); T. E. B. Bates (*Ch'n*, Darlington); Ald. W. T. Bates (*Mayor, Ch'n*, Derby); T. Baxter (*C'r*, Greenock); J. W. Beauchamp (*E.E.*, West Ham); A. J. Beckett (*E.E.*, Bridlington); Sir J. Beecham (*Ch'n.*, St. Helens); H. Bell (*E.E.*, Hull); J. A. Bell (*E.E.*, Aberdeen); L. C. F. Bellamy (*E.E.*, Ilkeston); C. R. Belling (Belling & Co.); W. J. Bellis (*C'r*, Wallasey); J. Belliss (Belliss & Morcom); Ald. Lord Belsfield (Todmorden); J. Bemrose (*E.E.*, Leek); R. Bennett (*Vice-Ch'n*, Dartford); W. C. Bexon (*E.E.*, Kilmarnock); J. Billington (*Ch'n*, Salford); Ald. T. P. Bird (*C'r*, Birmingham); G. J. Bish (Birmingham); A. S. Black (*E.E.*, Southport); A. S. Blackman (*E.E.*, Sunderland); J. A. Blackwood (Union Cable Co.); A. V. Bland (Chamberlain and Hookham); C. A. Blascheck (*E.E.*, Canterbury); T. W. Bloxam (*E.E.*, Belfast); W. W. Blunt (Westinghouse Co.); H. Blyth (Strachan and Henshaw); J. H. Bolam (*E.E.*, Weymouth); R. A. R. Bolton (London); H. Boot (London); J. W. Booth (*C'r*, Stockport); J. H. Bowden (*E.E.*, Poplar); W. Briggs (*C'r*, Lancaster); S. E. Britton (*E.E.*, Chester); H. Broadhurst (London); L. Broekman (Leeds); J. H. C. Brooking (St. Helen's Cable Co.); Ald. H. Brown (Leeds); Ald. W. Bruce (*Ch'n*, Sunderland); J. K. Brydges (*E.E.*, Eastbourne); J. B. Burman (*C'r*, Birmingham); H. R. Burnett (*E.E.*, Barrow-in-Furness); C. McArthur Butler (*Sec.* I.M.E.A.); T. O. Callender (Callender's

Cable Co.) ; —. Campbell (*C'r*, Brighton) ; R. H. Campion (*E.E.*, Dewsbury) ; L. S. Carr (*Constr. Eng*, Birmingham) ; John Chamberlain (Chamberlain & Hookham) ; S. Charlesworth (*C'r*, Bridlington) ; R. A. Chattock (*E.E.*, Birmingham) ; J. Christie (*E.E.*, Brighton) ; D. J. Clarke (*Ch'n*, Birkenhead) ; Major R. J. Clarke (*Dep. Ch'n*, Liverpool); —. Clarke (*C'r*, Sutton Coldfield); R. Clarke (Worcester) ; J. E. Clayton (*Ch'n*, Chesterfield) ; S. Clegg (*E.E.*, Lincoln) ; H. W. Clothier (A. Reyrolle & Co.) ; J. H. Clothier (*E.E.*, St. Anne's-on-Sea) ; T. D. Clothier (*E.E.*, Bootle) ; H. Coates (Voigt & Haeffner) ; G. H. Collins (Mansfield) ; A. G. Collis (Crompton & Co.) ; Ald. G. N. Colwill (Swansea) ; G. H. Cooke (Brown, Boveri & Co.) ; W. F. Cooke (*Ch'n*, Nelson) ; W. H. Cooke (*E.E.*, Luton) ; Ald. G. H. Coop (Ashton-under-Lyne) ; A. G. Cooper (*E.E.*, Colne) ; Ald. Sir G. W. Courtis (Cardiff) ; Coveney A. (*E.E.*, Erith) ; J. H. Craig (Glasgow) ; A. C. Cramb (*E.E.*, Croydon) ; G. F. Craven (*Trams. Eng'r*, Reading) ; W. Crawford (Belliss & Morcom) ; F. Crawter (London) ; A. J. Cridge (Electrical Co.) ; E. Crocker (*Instal. Eng.*, Birmingham) ; E. Cross (*E.E.*, Rotherham) ; Ald. W. Crow (*Mayor*, West Ham) ; J. A. Crowther (*E.E.*, Wallasey) ; J. P. Crowther (*E.E.*, Worksop) ; J. W. Crowther (*Ch'n*, Sheffield) ; E. W. Curtis, Jun. (Gen. Elec. Vehicle Co.) ; F. R. Davenport (Willans & Robinson) ; C. S. Davidson (*E.E.*, Barnes) ; Ald. R. C. Davies (*Ch'n*, Chester) ; W. H. Dawson (*C'r*, Plumstead) ; H. H. Denton (*E.E.*, Crewe) ; A. J. C. De Renzi (*E.E.*, Newcastle-under-Lyme) ; A. G. Deverill (Brush El. Eng. Co.) ; W. A. Dexter (Mirrlees, Watson Co.) ; J. R. Dick (Oxford) ; H. Dickinson (*E.E.*, Liverpool) ; H. L. Dixon (Leatherhead) ; T. Duesbury (*E.E.*, Sutton Coldfield) ; Councillor A. H. Dykes (*Ch'n*, Beckenham) ; E. R. Dymond (*Ch'n*, Hereford) ; Justus Eck (Union Electric Co.) ; J. E. Edgcome (*E.E.*, Kingston-upon-Thames) ; —. Edmeades (*C'r*, Winchester) ; A. G. Ellaway (*Ch'n*, Birmingham) ; A. Ellis (*E.E.*, Cardiff) ; H. S. Ellis (*E.E.*, S. Shields) ; J. E. Ellis (*E.E.*, Morley) ; D. M. Eunson (*E.E.*, Cambuslang) ; F. O. Everard (Birmingham) ; A. R. Everest (B.T.-H. Co.) ; G. W. Eyre (*Ch'n.*, Plymouth) ; J. Farr (*C'r.*, Nottingham) ; A. Fawcett (*C'r.*, Halifax) ; S. E. Fedden (*E.E.*, Sheffield) ; R. F. Ferguson (*E.E.*, Hastings) ; Dr. S. Z. de Ferranti (Hollingwood) ; Bailie Finlayson (Leith) ; Ald. J. S. Finnigan (*C'r.*, Belfast) ; Ald. S. Flint, (*Ch'n.*, Leicester) ; W. S. Foale (*E.E.*, Portsmouth) ; R. H. D. Forbes (Jandus Arc Lamp Co.) ; F. Forrest (*Sub-station Engineer*, Handsworth, Birmingham) ; Ald. F. G. Foster (*Ch'n.*, Portsmouth) ; H. Foulds (*Sec. Elec. Dept.*, Birmingham) ; W. E. Freir

(*Light Rly. & Tram. Jnl.*) ; H. F. Friederichs (*E.E.*, West Hartlepool) ; W. Frisby (*E.E.*, Colchester) ; C. Furness (*E.E.*, Blackpool) ; T. E. Gatehouse (*Electrical Review*) ; R. W. Gauntlett (Bruce, Peebles & Co.) ; Dr. H. Gervis (*Ch'n.*, Brighton) ; T. Gibb (*Ch'n.*, Aberdeen) ; Ald. W. P. Gibbings (*Ch'n*, Carlisle) ; J. H. Gibbs (*C'r.*, Bristol) ; R. Gibson (*Ch'n*, Wolverhampton) ; S. C. Gibson (*E.E.*, Nuneaton) ; J. C. Gill (*E.E.*, Peterborough) ; M. M. Gillespie (Gillespie & Beales) ; W. E. Gower (Underfeed Stoker Co.) ; H. R. Grant (*Ch'n*, Motherwell) ; H. Gray (*E.E.*, Accrington) ; J. P. Gregory (B.T-H. Co.) ; W. E. Groves (*Mains. Eng.*, Birmingham) ; A. E. Guest (Sutton Coldfield) ; K. O. Hale (Sturtevant Eng'g Co.) ; J. Haley (*C'r.*, Bradford) ; T. Hall (*E.E.*, Burton-on-Trent) ; R. Hammond (London) ; Bailie W. Hannay (*Vice-Ch'n*, Glasgow) ; J. W. Hargreaves (*C'r*, Burnley) ; A. Harrison (Birmingham) ; Haydn T. Harrison (London) ; J. Harrop (*C'r.*, Morley) ; F. Hawker (*C'r.*, Birmingham) ; W. C. C. Hawtayne (London) ; D. Hayward (Walsall) ; Ald. J. Heald (*Ch'n*, Lancaster); —. Heath (*C'r.*, Birmingham); Councillor A. Hemingway (Portsmouth) ; E. Hewlett (*E.E.*, Mansfield) ; Ald. G. Hickling (*C'r.*, St. Pancras) ; Clement Hill (*Ch'n*, Hastings) ; W. Hinde (*C'r.*, Whitehaven) ; Hugo Hirst (General Electric Co.) ; E. E. Hoadley (*E.E.*, Maidstone) ; W. F. Hobdell (Hobdell, Way & Co.) ; C. J. Hofton (Nottingham) ; L. B. Hogarth (*E.E.*, Whitehaven) ; E. Holden (Birmingham) ; P. Holden (Ferranti, Ltd.) ; E. M. Hollingsworth (*E.E.*, St. Helens) ; Ald. T. Holmes (Gillingham) ; W. Holmes (*E.E.*, Barking) ; T. Holt (*Dep. Ch'n*, Bury) ; J. F. Homer (*C'r.*, Birmingham).; Ald. T. Honebon (*Ch'n*, Weymouth) ; J. S. Huddleston (Siemens Bros. & Co.) ; G. Hughes (*C'r*, Wallasey) ; R. W. Hughman (*Electrical Times*, London) ; E. S. Hurlbatt (Dick, Kerr & Co.) ; Ald. S. Ingham (Southport) ; A. J. Ireland (B.T.-H. Co.) ; W. A. Jackson (*E.E.*, West Bromwich) ; E. S. Jacob (Tudor Accumulator Co.) ; W. Jamieson (*Ch'n.*, Bury) ; Ald. A. R. Jephcott (*C'r.*, Birmingham) ; E. J. Jewell (E. Green & Son) ; Ald. C. Johnson (*Vice-Ch'n.*, Hammersmith) ; S. D. Jones (*E.E.*, Batley) ; D. G. W. Joseph (*Ch'n*, Warrington) ; W. H. Jowett (*Ch'n.*, Morley) ; G. Kapp (Birmingham); R. J. Kaula (Willans & Robinson) ; Barnes Kay, (*E.E.*, Haslingden) ; R. W. Kennedy (*Electrical Industries*) ; W. T. Kerr (*E.E.*, Hereford) ; J. E. Kilburn (*Ch'n.*, Dewsbury) ; Ald. S. L. Kilpin (*Ch'n.*, Bedford) ; F. W. King (*Ch'n.*, Bootle) ; J. H. King (*C'r.*, Burton-on-Trent) ; Dr. W. Koch (Electrical Co.) ; E. M. Lacey (London) ; W. W. Lackie (*E.E.*, Glasgow) ; W. Langdon (*C'r*, Torquay) ; W. Lawson (*Meter & Motor Sup't.*,

Birmingham); J. E. Lea (Manchester); H. P. Lawson (Bradford); R. B. Leach (*E.E.*, Heywood); F. Lee (*Ch'n.*, Coventry); H. Tomlinson Lee (*E.E.*, Wimbledon); Ald. H. Leese (*Ch'n.*, Stoke-on-Trent); Ald. H. A. Leicester (*Mayor* of Worcester); R. Leigh (*C'r.*, St. Anne's-on-Sea); W. J. Lewis (London); Ald. H. W. Littler (*Ch'n.*, West Ham); Ald. S. Lloyd (*Dep. Ch'n.*, Bristol); A. Lofthouse (*C'r*, Harrogate); E. D. Long (*E.E.*, Grays); F. M. Long (*E.E.*, Norwich); B. Longbottom (Manchester); Ald. W. Longworth (*Ch'n.*, Bolton); W. S. Lonsdale (Siemens Dynamo Works); J. R. P. Lunn (*E.E.*, Darlington); D. Macallum (*C'r.*, Greenock); J. L. M'Donnell (*C'r.*, Belfast); J. P. McDougall (*Vice-Ch'n.*, Salford); C. F. McInnes (*E.E.*, Gravesend); H. F. S. Mackay (Stirling Boiler Co.); J. Y. Mackersie (*Res. Eng.*, Aston, Birmingham); R. V. Macrory (*E.E.*, Londonderry); W. L. Madgen (B.E.T. Co.); Sir H. Manton (*C'r.*, Birmingham); E. C. R. Marks (*C'r.*, Birmingham); A. Martin (Ald., Southend-on-Sea); Ald. M. Martin (*Ch'n.*, Eastbourne); Lieut.-Col. E. Martineau (L. Mayor, Birmingham); F. H. Masters (*Electrician*); F. V. L. Mathias (*E.E.*, Warrington); W. R. May (*E.E.*, Lowestoft); W. J. Merrett (*Ch'n.*, Cheltenham); P. F. Meyers (*Ch'n.*, Heston & Isleworth); H. E. Midgley (Fraser & Chalmers); Ald. D. B. Miller (*Ch'n.*, Croydon); W. H. Miller (*E.E.*, Fleetwood); G. C. Milnes (*E.E.*, Lancaster); W. E. Milns (*Com'l. & Cons'rs Eng.*, Birmingham); C. O. Milton (*E.E.*, Maidenhead) E. L. Morcom (Belliss & Morcom); R. K. Morcom (Belliss & Morcom); A. N. Moore (*E.E.*, Newport, Mon.); E. S. W. Moore (Rees Roturbo Mfg. Co.); J. Morgan (*C'r.*, Kingston-on-Thames); R. Moritz (*C'r*, Hornsey); T. Morley (*C'r*, Accrington); R. Morrin (*C'r*, Southport); L. R. Morshead (L. R. Morshead & Co.); G. Mortimer (British Aluminium Co.); F. Moss (*C'r*, Grimsby); Bailie J. M. Nairn (*Ch'n.*, Dundee); F. H. Nalder (Nalder Bros. & Thompson); E. A. Nash (Faraday House); G. F. Nayler (*E.E.*, Nelson); H. A. Nevill (*E.E.*, Wakefield); E. S. New (D.P. Battery Co.); F. A. Newington (*E.E.*, Edinburgh); F. A. Nield (Aron Elec. Meter, Ltd.); E. Norkett (*C'r*, Maidenhead); Ald. A. Nuttall (Blackburn); E. G. Okell (*E.E.*, Plymouth); Thos. Owen (Ed. Bennis & Co.); W. H. Owen (London); A. C. Pain (Birmingham); J. W. Papworth (*E.E.*, Stirling); G. B. Parrott (Birmingham); T. H. Parrott (Birmingham); H. H. Parsons (*C'r*, Accrington); G. E. Partington (W. T. Glover & Co.); S. Paul (*E.E.*, Middleton); S. L. Pearce (*E.E.*, Manchester); A. Pearson (*C'r.*, Dewsbury); Ald. G. Pearson (*Ch'n.*, Bristol); H. A. Pearson (Reason Mfg.

Co.); Ald. W. Pearson (*Ch'n.*, Eccles); J. D. Pember (*E.E.*, Dartford); R. W. L. Phillips (*E.E.*, Bedford); W. G. Pickvance (*E.E.*, Wrexham); W. N. Pilkington (*C'r*, St. Helens); C. Pipkin (Callender's Cable Co.); J. S. Plumtree (Union Elec. Co.); E. Poole (Hayle, Cornwall); A. Potts (*C'r.*, Bolton); —. Pounder (*C'r*, Ilkeston); R. Pritchard (*C'r.*, Liverpool); H. Faraday Proctor (*E.E.*, Bristol); F. W. Purse (*E.E.*, Carlisle); J. Pybus (*C'r.*, Hull); P. J. Pybus (Phœnix Dynamo Co.); A. Railing (General Electric Co.); P. N. Rand (Westinghouse Co.); H. Ranson (*E.E.*, Falkirk); F. C. Raphael (*Electrical Engineering*); E. S. Rayner (*E.E.*, Doncaster); —. Reading (*C'r.*, Birmingham); W. Redman (*E.E.*, Shipley); T. Reeves (*Dep. Ch'n.*, Rotherham); T. R. Renfree (British Elec. Trans. Co.); E. Reynolds (*C'r.*, Shipley); H. Richardson (*E.E.*, Dundee); G. M. Robertson (*Ch'n.*, Fleetwood); J. A. Robertson (*E.E.*, Salford); J. K. Robertson (Strachan & Henshaw); W. Robson (Jandus Arc Lamp Co.); Ald. G. H. Robinson (*Ch'n.*, Bradford); I. V. Robinson (Richardsons, Westgarth); W. M. Rogerson (*E.E.*, Halifax); T. Roles (*E.E.*, Bradford); B. I. Rolling (Glasgow); Ald. Rose (Barnsley); A. Rowse (Birmingham); H. S. Russell (Mirrlees, Bickerton & Day); A. P. Rutherford (*E.E.*, Leith); P. Rycroft (*E.E.*, Heston & Isleworth); C. W. Salt (*E.E.*, Torquay); T. Sauvage (*C'r*, Wrexham); Ald. J. Schofield (*Vice-Ch'n.*, Stoke-on-Trent); R. H. Schofield (Ferranti, Ltd.); H. Scholey (Scholey & Co.); A. H. Seabrook (*E.E.*, St. Marylebone); G. D. Seaton (Richardsons, Westgarth); W. M. Selvey (Sheffield); J. Senior (*E.E.*, Mexborough); G. P. Shallcross (*E.E.*, Birkenhead); E. E. Sharp (Venner & Co.); A. H. Shaw (*E.E.*, Ilford); C. M. Shaw (*E.E.*, Worcester); C. E. C. Shawfield (Knowles Oxygen Co.); Ald. C. F. Simmons (Eastbourne); P. J. Sims (General Electric Co., Glasgow); A. Sinclair (*Ch'n.*, Swansea); S. M. Slater (*C'r*, Walsall); Ald. J. P. Smith (*Ch'n.*, Barrow-in-Furness); E. S. Smith (British Elec. Equipment Co.); Ald. F. Smith (*Ch'n.*, Liverpool); Ald. G. Smith (*C'r.*, Doncaster); J. J. Smith (*E.E.*, Stockton-on-Tees); R. W. Smith (Drake & Gorham); T. R. Smith (*E.E.*, Leicester); Bailie W. G. Smith (*Ch'n.*, Glasgow); Sir J. F. C. Snell (London); N. Staniland (*E.E.*, Hornsey); J. W. Stansfield (*C'r.*, Rawtenstall); J. E. Starkie (*E.E.*, Burnley); C. W. Starmer (*C'r.*, Darlington); J. G. Statter (Switchgear & Cowans); Judge Stevenson (Edinburgh); C. L. E. Stewart (*E.E.*, Rawtenstall); P. Stirling (*Mayor, Ch'n.*, Doncaster); A. J. A. Stone (*C'r*, Cardiff); G. D. Stone (Mirrlees, Watson Co.); Dudley Stuart (*Ch'n.*, Wimble-

don) ; T. T. Sykes (*C'r*, Stockport) ; P. H. Symonds (Willans & Robinson) ; Ald. Tatham (Ilkeston) ; C. D. Taite (Lancashire Electric Power Co.) ; B. A. Tapp (*Electrical Review*) ; J. E. Tapper (*E.E.*, Beckenham) ; W. C. P. Tapper (*E.E.*, Stepney) ; A. M. Taylor (*Ass't. Eng.*, Birmingham) ; H. M. Taylor (*E.E.*, Middlesbrough) ; T. Taylor (Mansfield) ; J. E. Teasdel (*E.E.*, Pontypridd) ; A. E. Thomas (*C'r*, Bristol) ; Bertram Thomas (Manchester) ; A. Thomson (*Ch'n.*, Ayr) ; C. S. Thomson (Vicars, Ltd.) ; Major H. Tomkins (*Ch'n.*, Stockton-on-Tees) ; L. Tomlinson (*Dep. Ch'n.*, Bootle) ; R. N. Torpy (*E.E.*, Tunbridge Wells) ; G. Tough (*E.E.*, Coventry) ; A. R. Tudman (*E.E.*, Colwyn Bay) ; C. Turnbull (*E.E.*, Tynemouth) ; A. T. Turney (Western Electric Co.) ; J. C. Vaudrey (Birmingham) ; Ald. E. Vaughan (*Ch'n.*, Maidstone) ; A. Verdie (Craigpark Elec. Cable Co.) ; W. A. Vignoles (*E.E.*, Grimsby) ; J. Walker (*C'r.*, Hull) ; J. Walker (*C'r*, Rochdale) ; W. E. Warrilow (*Electrician*): S. J. Watson (*E.E.*, Bury) ; F. H. Way (Electrical Apparatus Co.) ; H. J. Groves Webb (Electrical Co.) ; A. Webster (*Electrical Engineering*) ; Ald. C. West (*C'r.*, Coventry) ; W. Wheal (Worcester) ; P. P. Wheelwright (*E.E.*, Blackburn) ; Ald. Wilkins (*Ch'n*, Derby) ; Ald. A. Wilkinson (Luton) ; G. Wilkinson (*E.E.*, Harrogate) ; H. Wilkinson (*E.E.*, Radcliffe) ; H. T. Wilkinson (Wardle Eng. Co.) ; J. Wilkinson (*C'r*, Warrington) ; T. Wilkinson (*C'r.*, Lancaster) ; A. M. Willcox (*Tram. & Rly. World*) ; Bailie J. Willock (*C'r.*, Glasgow) ; T. P. Wilmshurst (*E.E.*, Derby) ; C. Wilson (Osram Lamp Works) ; Ald. J. H. Wilson (*Ch'n.*, Hornsey) ; R. J. Wilson (*Vice-Ch'n.*, Sunderland) ; E. Wilson (Birmingham) ; Ald. D. L. Winter (Rotherham) ; J. A. Wishart (*E.E.*, Motherwell) ; H. Womersley (*Ch'n.*, Wakefield) ; A. P. Wood (Lancashire Dynamo Co.) ; W. C. Wood (*C'r.*, St. Pancras) ; W. J. H. Wood (*E.E.*, Bolton) ; L. W. Woodman (*E.E.*, Dover) ; W. Woods, (Birmingham) ; C. H. Wordingham (Admiralty) ; W. Wyld (*E.E.*, Hampstead) ; C. H. Yeaman (*E.E.*, Stoke-on-Trent).

Ladies.—Mrs. Allen, Runcorn ; Mrs. Allen, Wolverhampton ; Mrs. Ashworth, Heywood ; Mrs. Bailes, Liverpool ; Mrs. George Ball, Stockport ; Mrs. A. E. Barker, Barnsley ; Mrs. M. Bates, Coventry ; Mrs. Bell, Aberdeen ; Mrs. H. Bell, Hull ; Mrs. F. C. Bellamy, Ilkeston ; Mrs. J. Bemrose, Leek ; Mrs. Bernard, Walsall ; Miss Bird, Birmingham ; Mrs. Bolam, Weymouth ; Miss G. Bower, Sheffield ; Mrs. J. E. Britton, Chester ; Mrs. Broadhurst, London ; Mrs. Bunting, Blackpool ; Mrs.

Burman, Birmingham ; Mrs. Burnett, Barrow ; Mrs. Burr Higgs, Birmingham ; Mrs. Chattock, Birmingham ; Mrs. Christie, Brighton ; Mrs. D. J. Clarke, Birkenhead ; Mrs. H. W. Clothier, Wallsend ; Mrs. Cooper, Colne ; Mrs. Craven, Reading ; Mrs. Crooker, Birmingham ; Mrs. Cross, Rotherham ; Mrs. Crowther, Sheffield ; Mrs. R. Cecil Davies, Chester ; Mrs. Dickinson, Liverpool ; Mrs. Evans, Birmingham ; Mrs. Fedden, Sheffield ; Mrs. Ferguson, Hastings ; Mrs. Furness, Blackpool ; Mrs. Gibb, Aberdeen ; Mrs. Gower, Manchester ; Mrs. Groves, Birmingham ; Mrs. Haley, Bradford ; Mrs. Hall, Burton ; Mrs. Hargreaves, Burnley ; Mrs. H. Harrison, London ; Mrs. Holden, Birmingham ; Mrs. Homer, Birmingham ; Mrs. Jephcott, Birmingham ; Mrs. E. J. Jewell, Birmingham ; Mrs. W. Koch, London ; Mrs. W. Lackie, Glasgow ; Mrs. Lawson, Birmingham ; Mrs. Lee, Coventry ; Mrs. Littler, West Ham ; Mrs. Longworth, Bolton ; Mrs. Mackensie, Birmingham ; Mrs. McInnes, Gravesend ; Mrs. Merrett, Cheltenham ; Mrs. Nuttall, Blackburn ; Miss Patterson, Hayle ; Mrs. Pearce, Manchester ; Mrs. G. Pearson, Bristol ; Mrs. Poole, Hayle ; Mrs. W. Faraday Proctor, Bristol ; Mrs. Robinson, Bradford ; Mrs. Rogerson, Halifax ; Mrs. Roles, Bradford ; Miss Rowse, Birmingham ; Mrs. Rycroft, Hounslow ; Mrs. Shawfield, Bromborough ; Miss. Ella Sisson, Birmingham ; Mrs. J. J. Smith, Stockton ; Mrs. Stewart, Rochdale ; Mrs. Dudley Stuart, Wimbledon ; Mrs. Tough, Coventry ; Miss Vaudrey, Birmingham ; Miss Vernon, Rotherham ; Mrs. W. A. Vignoles, Grimsby ; Mrs. J. Walker, Hull ; Mrs. Geo. Wilkinson, Harrogate ; Mrs. W. J. Wilkinson, Manchester ; Mrs. J. Willock, Glasgow ; Mrs. Williams, Birmingham ; Mrs. Wood, Newport ; Mrs. Wordingham, Redhill.

Incorporated Municipal Electrical Association.

Studentship Scheme.

Regulations and Conditions.

(1). The Council offers travelling studentships of the value of £10 each, for competition among Associates of the I.M.E.A., in the proportion of one studentship to every hundred Associates, or such other proportion as the Council may from time to time determine.

(2). Competitors shall be persons whose names are on the roll of Associates and who have paid their subscription for the current year.

(3). The Studentships will be awarded annually for the best papers submitted before March 31st on an approved subject, the holder being required to undertake before December 31st a tour of not less than one week's duration, for the purpose of visiting Electricity and Engineering Works.

(4). The successful candidates must within fourteen days of the award, notify the Secretary of the date of the commencement of the tour and particulars of the proposed itinerary and the works which it is desired to visit. They will then receive a sum of £7, and a travelling card of identification.

(5). A diary of the tour must be kept, which together with a detailed descriptive report must be sent to the Secretary within a month of the completion of the tour.

(6). Subject to the Council being satisfied from the evidence submitted that the holder has made proper use of his opportunties, a further payment of £3 will be made.

(7). All papers, etc., submitted in connection with the competition become the property of the Council.

(8). The Studentship may only be held once by the same person.

(9). The Council reserves the right of withholding any or all of the awards at its discretion.

All communications must be addressed to:—

C. McARTHUR BUTLER,
28, Bedford Square, W.C.

Winner of Studentship, 1907:—Mr. R. McCourt, Harrogate.
" " 1908:—Not awarded.
" " 1909:—Mr. E. Lunn, Huddersfield.
" " 1910:—Not awarded.
" " 1911:—Mr. V. T. Bush, Tunbridge Wells.
" " 1912:—Not awarded.
" " 1913:—Not awarded.
" " 1914:—Not awarded.

Incorporated Municipal Electrical Association.

FOUNDED 1895. INCORPORATED 1901.

LIST OF MEMBERS.

(*Those Municipalities in large type are represented on the Council.*)

COMMITTEES.

Date of Election.		Date of Election.	
1905	Aberdeen	1896	BRIGHTON
1902	Accrington	1896	BRISTOL
1901	Ashton-under-Lyne	1896	Burnley
1897	Ayr	1906	
1906	Barking	1904	Burton-upon-Trent
1900	Barnsley	1899	BURY
1898	BARROW-IN-FURNESS	1910	Cambuslang
		1907	Canterbury
1897	Bath	1897	Cardiff
1906	Beckenham	1900	Carlisle
1896	Bedford	1896	Cheltenham
1902	Birkenhead	1898	Chester
1903	Birkenhead Tramways	1901	Chesterfield
1904	BIRMINGHAM	1912	Clacton-on-Sea
1908	Blackburn	1900	Colchester
1897	BLACKPOOL	1900	Colne
1896	Bolton	1912	Colwyn Bay
1903	Bolton Tramways	1896	Coventry
1902	Bootle	1909	Crewe
1903	Bournemouth Tramways	1896	CROYDON
1896	BRADFORD	1900	Darlington
1909	Bridlington	1914	Dartford

Date of Election	
1898	Darwen
1898	Derby
1893	Devonport
1896	Dewsbury
1901	Doncaster
1906	Dover
1903	Dublin
1901	DUNDEE
1899	Ealing
1900	Eastbourne
1904	Eccles
1901	Edinburgh
1908	Epsom
1903	Erith
1897	Exeter
1905	Falkirk
1904	Fulham
1908	Gillingham
1896	GLASGOW
1903	Gloucester
1904	Gravesend
1899	Great Grimsby
1908	Greenock
1896	Halifax
1897	Hammersmith
1912	HAMPSTEAD
1897	HARROGATE
1899	Hastings
1902	Heckmondwike
1912	Hereford
1914	Heston & Isleworth
1902	Heywood
1908	Hornsey
1908	Horsham
1901	Hoylake
1896	Huddersfield
1897	Hull
1902	Hull Tramways
1902	Ilford
1903	Ilkeston
1906	Keighley
1907	Kilmarnock
1906	King's Lynn
1896	KINGSTON-UPON-THAMES
1902	Lancaster
1901	Leeds
1905	Leek
1911	Leicester
1901	Leigh
1908	Leith
1901	Leyton
1897	Lincoln
1896	Liverpool
1903	Londonderry
1906	Loughborough
1899	Lowestoft
1896	Luton
1897	Maidenhead
1902	Maidstone
1896	MANCHESTER
1904	Mansfield
1913	Melbourne, Australia
1902	Middlesbrough
1902	Middleton
1898	Morley
1901	Motherwell
1902	Nelson

Date of Election.		Date of Election.	
1897	Newport (Mon.)	1896	Sunderland
1907	Northampton	1913	Sutton Coldfield
1909	Norwich	1902	SWANSEA
1903	Nottingham	1902	Swindon
1902	Nuneaton	1896	Taunton
1903	Oldham	1909	Todmorden
1909	Pembroke (Dublin)	1897	Torquay
1896	Plymouth	1896	Tunbridge Wells
1908	Pontypridd	1903	Tynemouth
1912	Poplar	1901	Wakefield
1904	Portsmouth	1896	Wallasey
1901	Reading Tramways	1896	Walsall
1908	Radcliffe	1908	Warrington
1910	Rawtenstall	1897	Watford
1896	Rochdale	1913	West Bromwich
1897	Rotherham	1897	West Ham
1897	Salford	1906	Weymouth
1904	SHEFFIELD	1912	Whitehaven
1901	Shipley	1901	Wigan
1897	Southampton	1900	Willesden
1896	Southend-on-Sea	1908	Wimbledon
1897	Southport	1912	Winchester
1902	South Shields	1906	Wishaw
1903	St. Annes-on-Sea	1898	WOLVERHAMPTON
1898	St. Helen's	1906	Woolwich
1899	St. Pancras	1896	Worcester
1902	Stockton	1913	Worksop
1903	Stoke-on-Trent	1903	Wrexham
1898	Stockport	1901	York

ELECTRICAL ENGINEERS (MEMBERS)

Names of Members of Council are in larger type

Date of Election.		
1901	Acland, R. L.	Chesterfield
1900	Atchison, C. C.	Rochdale
A 1902 M 1908	Allen, Sidney	Wolverhampton
1909	Allen, W. H.	Loughborough
1902	Angus, H. W.	Eccles
1914	Annetts, A. W.	Morecambe
1901	Applebee, N.	Ashton-under-Lyne
1906	AYTON, F.	Ipswich
1912	Ayton, R.	Winchester
1903	Bache, W. J.	Cheltenham
1913	Barham, A. W.	Watford
1903	Barker, E. A.	Barnsley
1910	Beauchamp, J. W. ..	West Ham
1913	Beckett, A. T.	Bridlington
1903	Bell, H.	Hull
A 1896 M 1899	Bell, J. A.	Aberdeen
1913	Bellamy, L. C. F. ..	Ilkeston
1914	Bemrose, J.	Leek
1912	Bexon, W. C.	Kilmarnock
1908	Black, A. S.	Southport
1896	Blackman, A.	Sunderland
1912	Blake, A. W.	Willesden
1907	Blascheck, C. A.	Canterbury
1908	Bloxam, T. W.	Belfast
1908	Bolam, J. H.	Weymouth
1896	Boot, H. (*Past Member of Council* 1906)	Tunbridge Wells
1906	Bowden, J. H.	Poplar, E.
1901	Britton, S. E.	Chester
1898	Brydges, J. K. (*Past Member of Council* 1908)	Eastbourne

Date of Election.		
1905	Bulfin, I.	Bournemouth
A 1896 M 1898	Burnett, H. R.	Barrow-in-Furness
1901	Calvert, E.	Finchley, N.
1902	Campion, R. H. ..	Dewsbury
1907 1913	Chalmers, A. D... ..	Gillingham
1900	CHATTOCK, R. A. (*President* 1913–14)	Birmingham
M 1895 A 1898 M 1900	CHRISTIE, J. .. .. (*Past President* 1911.)	Brighton
A 1896 M 1898	Clegg, Stanley	Lincoln
1902	Clothier, J. H.	St. Anne's-on-Sea
A 1898 M 1902	Clothier, T. D.	Bootle
1902	Cooke, W. H.	Luton
A 1895 M 1900	Cooper, A. G.	Colne
1914	Corson, F. H.	Gloucester.
A 1900 M 1904	CRAMB, A. C. .. .. (*Vice-President* 1913–14)	Croydon
1913	Craven, G. F.	Reading
1909	Cross, E.	Rotherham
1900	Crowther, J. A... ..	Wallasey
1901	Crowther, J. P... ..	Worksop
1902	Davidson, C. S... ..	Mortlake, S.W.
1913	De Renzi, A. J. C. ..	Newcastle-under-Lyne
1896	Dickinson, H. (*Past Vice-President* 1901)	Liverpool
1903	Dimmack, A.	Swindon
1904	Duesbury, T.	Sutton Coldfield
1895	EDGCOME, J. E. (*Hon. Treas. Past Pres.* 1906, *Hon. Secretary* 1904)	Kingston-upon-Thames

Date of Election.		
1895	Ellis, A. (*Past Member of Council* 1902)	Cardiff
1912	Ellis, H. S.	South Shields
1909	Everitt, H. W.	Clacton-on-Sea
A 1896 / M 1899	FEDDEN, S. E. .. (*Past President* 1907)	Sheffield
1903	Ferguson, R. F. ..	Hastings
1903	Foale, W. S.	Portsmouth
1909	Francis, O. F.	Kirkcaldy
1901	Friederichs, H. F. ..	West Hartlepool
1899	FURNESS, C.	Blackpool
1905	Garside, F.	Aldershot
1912	Gibson, S. Cameron ..	Nuneaton
1901	Gill, J. C.	Peterborough
1903 / 1913	Gilling, A. C.	Epsom
1906	Goslin, E. T.	Glasgow Trams
1901	Grey, H.	Accrington
1911	Hall, T.	Burton-upon-Trent
A 1906 / M 1908	Hame, J. W.	York
1906	Hatton, E.	Newcastle-upon-Tyne
1911	Hawkins, H. J.	
1904	Hewlett, E. H.	Mansfield
A 1898 / M 1900	Hoadley, E. E. (*Past Member of Council* 1907)	Maidstone
1910	Hogarth, L. B.	Whitehaven
A 1899 / M 1903	Hollingsworth, E. M. ..	St. Helen's
1914	Holmes, W.	Barking
1907	Jackson, W. A.	West Bromwich
1913	Kay, Barnes	Haslingden
1909	Kerr, W. T.	Hereford
1903	Kinghorn, D. M. ..	Southwark, S.E.
1900	Knight, J. D.	Ealing, W.

Date of Election.		
A 1896 AM 1898 M 1905	Lackie, W. W. .. .. (*Past President* 1910)	Glasgow
1906 1913	Leach, R. B.	Heywood
1913	Lee, H. Tomlinson ..	Wimbledon
1898	Lewis, F. H.	Leytonstone, E.
1909	Lomax, R.	Stockport
1908	Long, E. D.	Grays Thurrock
1903	Long, F. M. (*Past Member of Council*, 1912)	Norwich
A 1896 M 1901	Lunn, J. R. P.	Darlington
1901	Macrory, R. V.	Londonderry
1903	Marshall, R.	Ayr
1908	Mathias, F. V. L. ..	Warrington
1914	May, W. R.	Lowestoft
1903	McInnes, C. F.	Gravesend
1913	Miller, H. W.	Fleetwood
1911	Milnes, G. C.	Lancaster
1912	Moore, A. Nichols ..	Newport, Mon.
A 1896 M 1898	Morton, A. H.	Llandudno
1895	Mountain, A. B. (*Past Pres.* 1900, *and Hon. Secretary* 1896)	Huddersfield
1896	Munro, H. D.	Exeter
1913	Nayler, G. F.	Nelson
1909	Nevill, H. A.	Wakefield
1896	Newington, F. A. (*Past President* 1905)	Edinburgh
A 1897 M 1901	Okell, E. G.	Plymouth
1905	Page, A.	Glasgow
1910	Papworth, J. W. ..	Stirling
1898	Parkinson, C. F. ..	Paisley

Date of Election		
1904	Pauls, S.	Middleton
AM 1903 M 1904	PEARCE, S. L. .. (*Past-President* 1909)	Manchester
1901	Pember, J. D.	Dartford
A 1896 M 1902	Phillips, R. W. L. ..	Bedford
1909	Pickersgill, A.	Cleckheaton
1909	Pickvance, G.	Wrexham
1906	Plunkett, M. P.	Tonbridge
1912	Price, S. L. R.	Pembroke (Dublin)
1895	PROCTOR, H. FARADAY (*Hon. Secretary, Past Pres.* 1899)	Bristol
A 1897 M 1900	Prusmann, C. A. L. ..	Swansea
1909	Purse, F. W.	Carlisle
1912	Ranson, H.	Falkirk
1904	Rayner, E. S.	Doncaster
1913	Redman, W.	Shipley
1904	RICHARDSON, H. .. (*President* 1914-15)	Dundee
1904	Robertson, J. A. ..	Salford
1902	Robinson, L. L.	Hackney, N.E.
1902	Rogerson, W. M. ..	Halifax
1908	ROLES, T.	Bradford
1902	Ruddle, M.	Dublin
1904	Rutherford, A. P ..	Leith
1911	Rycroft, P. E.	Hounslow
1911	Salt, C. W.	Torquay
1908	Sankey, B.	Port Elizabeth
1902	SEABROOK, A. H. ..	St. Marylebone
1909	Senior, J.	Mexborough
1901	Shaw, A. H.	Ilford, E.
1903	Shaw, C. M.	Worcester
1906	Slevin, J.	Wigan

Date of Election.		
1906	Smith, Arthur T. ..	Leigh, Lancs.
1903	Smith, J. J.	Stockton-on-Tees
1912	Smith, T. R.	Leicester
1903	Spark, J. W.	Devonport
1904	Staniland, N.	Hornsey, N.
1906	Starkie, J. E.	Burnley
1910	Stewart, C. L. E., ..	Rawtenstall
1910	Stokes, H. P.	Bexley Heath
1901	Street, H. F.	Southampton
1895	Talbot Herbert .. .. (*Past President* 1908)	Nottingham
1909	Tapper, J. E.	Beckenham
A 1896 M 1900	Tapper, W. C. P. ..	Stepney, E.
1902	Taylor, H. M.	Middlesbrough
1898	Teague, F.	Bath
A 1896 M 1906	Teasdel, J. E.	Pontypridd
1913	Torpy, R.N.	Tunbridge Wells
1910	Tough, G.	Coventry
1909	Tudman, A. R. ..	Colwyn Bay
1900	Turnbull, C.	Tynemouth
1908	Turnbull, J. L. ..	Broughty Ferry
1907	Turner, C.	Hoylake
1901	Vignoles, W. A.	Grimsby
1911	Walker, W. A.	Kettering
1898	WATSON, S. J.	Bury
1910	Webber, H.	Keighley
AM 1904 M 1905	Wheelwright, P. P. ..	Blackburn
1909	Whysall, F. H.	Greenock
1897	WILKINSON, G. .. (*Past President*, 1912)	Harrogate
1914	Wilkinson, H.	Radcliffe

Date of Election.		
1903	Wilkinson, J.	Hull Tramways
1895	Wilmshurst, T. P. (*Past Pres.*, 1904)	Derby
1907	Wilson, W. H.	Sleaford
1911	Wishart, J. A.	Motherwell
1913	Wood, W. J. H.	Bolton
1906	Woodman, L. W. ..	Dover
1897 / M 1902	WYLD, W. (*Member of Council*)	Hampstead
A 1896 / M 1905	Yeaman, C. H.	Stoke

HON. MEMBERS.

M 1898 / 1905	Chamen, W. A. (*Past Pres.*, 1901)	Cardiff
M 1896 / 1903	Holmes, A. B. (*Past Mem. of Council*, 1898)	Liverpool
M 1895 / 1911	Rider, J. H. (*Past Pres.*, 1901–2)	Johannesburg
M 1898 / 1913	Shawfield, C. E. C. (*Past Pres.* 1912–13)	Wolverhampton
M 1906 / 1909	Snell, Sir J. F. C. (*Past Pres.* 1902-3)	London
M 1895 / 1910	Wordingham, C. H. .. (*Past President* 1898)	London

ASSOCIATE MEMBERS.

CHIEF ASSISTANT ENGINEERS

1912	Hudson, J. Barcroft ..	Bootle
1905	Lamb, C.	Dundee
1907	Ratcliff, H. A.	Manchester
1910	Yorke, W.	Sunderland

ASSOCIATES.

ASSISTANT ENGINEERS.

Date of Election.		
1903	Boyce, J.	Todmorden
1911	Bush, V. F.	Canning Town, E.
1901	Cairns, R.	Glasgow
1902	Channon, A. S.	Grimsby
1903	Day, S. E.	Bury St. Edmunds
1910	Dent, J. H.	Loughborough
1906	Douglas-Arden, G.	Derby
1904	Fairchild, J. C.	St. Annes-on-Sea
1899	Gilbert, A. C.	Edinburgh
1911	Hooper, W. P.	Dewsbury
1901	Howell, A.	Hornsey, N.
1904	James, E. W.	Hounslow, W.
1902	Jones, S. Derwen	Batley
1904	Lowe, J. W.	Wigan
1909	Lunn, E.	Huddersfield
1897	May, H. S.	London
1912	McDonnell, E. C.	Bootle
1902	Millington, W. G.	Peterborough
1899	Milton, C. O.	Maidenhead
1903	Nixon, A. T.	Sheffield
1902	Ogden, F. L.	Oldham
1896	Philpott, G. J.	Brighton
1904	Rolling, B. I.	Glasgow
1911	Saxton, C.	Bradford
M 1897 / A 1898	Shallcross, G. P	Birkenhead
1902	Thomson, J.	Leith
1898	Turner, J. W.	Huddersfield
1897	Whitwham, A. E.	Huddersfield
1902	Young, W.	Stepney, E.

SUMMARY.

Committees.	Members	167
Engineers.	„	174
„	Hon. Members	6
Assistants.	Associate Members	4
„	Associates	29
		380

PUBLICATIONS

OF THE

Incorporated Municipal Electrical Association

Author.	Title.	Date.
ACLAND, R. L.	Extension of Electricity Supply to outlying districts - - - - -	1907
ANDREWS, L.	The Distribution of Electricity in Scattered Areas - - - - -	1900
AYTON, F.	Cheapening of the Cost of Mains and Services - - - - - - -	1910
	Means for Securing Reliability and Maintaining Continuity of Supply -	1912
BARNARD, A. S.	Electricity Supply at 220 Volts. - -	1896
	High Tension Continuous Current Systems - - - - - -	1902
BAYNES. S. W	Steam Turbines - - - - - -	1906
BEAUCHAMP, J. W.	Modern Wiring Practice - - -	1911
BISHOP, H. COLLINGS	Means for Stimulating a Demand for Electrical Energy - - - -	1900
	The Commercial Development of Electricity Undertakings- - -	1906
	Notes on the Commercial Progress of Electricity Undertakings - - -	1910
BLACKMAN, A. S.	Steam Turbines from the User's Point of View - - - - - - - -	1909
BLAIKIE, J. R.	Distributing Systems - - - -	1897
	Switchboard Apparatus - - -	1898
BLAKEWAY, COUNCILLOR.	The Financial Possibilities of Municipal Electrical Undertakings - - -	1904
BOOT, H. L. P.	Street Lighting by Electricity - -	1897
	Method of Reducing Light and Load Losses - - - - - - -	1900
	The Management and Working of Boilers	1903
BOWDEN, J. HORACE -	The Standardization of Tariffs - -	1914
BREMNER, ASHTON	Extensions to existing Electricity Supply Stations by means of Mixed Pressure Turbines - - - - - - -	1910
BURNETT, H. P.	The Costs of Electrical Supply and their Relation to Scales of Charges	1907
BUSH, VALENTINE F.	The Motor Meter as applied to the Measurement of Single Phase Alternating Current - - - - -	1911
CARR, R. M.	Internal Combustion Engines in Power Stations - - - - - -	1911

Author.	Title.	Date.
CHAMEN, W. A.	Presidential Address	1901
	The Possibilities of Future Economies in Electrical Illumination	1903
CHATTOCK, R. A.	Coal and Ash Conveying Gear	1901
	Presidential Address	1914
CHRISTIE, J.	Presidential Address	1911
	Air Filtration	1913
CLOTHIER, T. D.	Electric Lighting Mains	1899
COUZENS, H. W.	Alternating Current Stations and High Voltage Lamps	1896
	Prepayment Meters	1897
CRAMB, A. C.	Commercial Advancement of Electrical Supply	1910
CRIDGE, A. J.	The Organisation and Management of a Central Station Meter Department	1904
	Some Notes on Alternating Current Distribution	1907
DAY, ARTHUR A.	The Correct Type of Engine for Large Generating Stations	1902
DOWNE, R. S.	Boiler House Economies	1904
EDGCOME, J. E.	The Arrangement of Steam and other Pipes, and their Fittings	1899
	Presidential Address	1906
FEDDEN. S. E.	Street Lighting by Electricity	1897
	Steam Turbines	1902
	The Commercial Development of Electricity Undertakings	1906
	Presidential Address	1907
	The Design and Operation of Modern Boiler House Plant	1914
FELL, A. L. C.	Braking Apparatus for Electric Cars	1901
FERRANTI S. Z. DE	Prime Movers for Electric Power	1913
GIBBINGS, A. H.	Extensions to Outlying Districts	1896
	Municipal Aids to Wiring	1897
	Presidential Address	1898
HARRIS, G. M.	Electricity Works for Small Towns	1900
HESFORD, COUNCILLOR.	The Management of Electricity Undertakings	1898
HESKETH & RIDER.	Combined Electric Lighting and Traction plants	1896
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HIGHFIELD, J. S.	Refuse Destructors in Combination with Electric Power Stations	1901
HOADLEY, E. E.	Street Lighting	1905
	The influence of metallic filament lamps on the Electrical industry and on Street Lighting	1909

Author.	Title.	Date.
Hodgson, Councillor.	The Supply of Electricity in Industrial Areas from a Municipal Point of View	1905
Hollingsworth, E. M.	Modern Cable Systems - - -	1909
Holmes, H. H.	Electric Cooking Apparatus- - -	1912
Howard, H. L.	Internal Combustion Engines in Power Stations - - - - - - -	1911
Howard, H.	Steam Turbines : Their Efficiency compared with Reciprocating Engines -	1904
Jeckell, J. A.	Cable Specifications and Tests - -	1896
	Distributing Systems - - - -	1897
	Steam Using Plant - - - -	1898
	The Financial Improvement of Electricity Supply Works - -	1903
Kilgour, H.	Notes on Costs and Tariffs for Electric Supply - - - - - -	1905
Lackie, W. W.	Presidential Address - - - -	1910
Le Rossignol, A. E.	Impressions of Present American Tramway Practice - - - - -	1900
	Electric Traction as Applied to the Newcastle Tramways - - -	1903
Leese, Councillor H.	Electricity Supply viewed from the Municipal Committee's Standpoint -	1911
Long, F. M.	A Cooking Load from the Supply Station point of view. - - -	1912
Lunn, E.	Notes on Condensing and Water Cooling Plant - - - - - -	1906
Lunn & Thompson.	Notes on the Performances of Single Phase Motors - - - - - -	1899
Maclay, Bailie	Appropriation of Profits and Repayments of Loans - - - -	1898
	Do. do. do. - - - -	1899
	Notes on Street Lighting - -	1901
McCourt, R.	The Value of Photometry in Central Station Practice - - - - -	1907
Mountain, A. B.	Electricity Works Records - - -	1896
	The Municipalisation of the Telephone -	1899
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Murray, J. R. Campbell	Steam Power Generation. The Advantages of Mechanical Draft - -	1911
Newington, F. A.	Presidential Address - - - -	1950
	Exhaust Steam Turbines and Condensing Plant - - - - -	1910

Author.	Title.	Date.
PANTON, COUNCILLOR	Some Observations on Electricity Supply and Methods of Stimulating Demand	1903
PEARCE, S. L.	Polyphase Sub-stations: Their Equipment and Working	1904
	Presidential Address	1909
	The Limitation of Rate Relief from Profits	1912
PEARSON, ALDERMAN.	Municipal Trading	1899
	The Sphere of Utility of a Power Company	1903
POTTER, ALDERMAN.	Means for stimulating Demand for Electrical Energy	1900
PROCTOR, H. FARADAY	Presidential Address	1899
	Notes *re* Earthing	1902
	Some Notes on the Bristol Electricity Fire-	1904
PRUSSMANN, C. A. L.	The Choice of Meters	1899
	Electric Motors	1900
QUIN, R. C.	Localisation of Faults	1897
	Electric Traction	1900
	Protection of Telegraph and Telephone Wires	1900
RATCLIFF H. A.	The Work and Equipment of a Testing and Standardising Department	1908
REID, A. M.	Reliability of the "Total Costs per Unit Sold"	1913
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SHAW, C. M.	The Reconstruction of an Electric Lighting Scheme	1908
	Organization in Electricity Supply Undertakings	1912
SHAWFIELD, C. E. C.	The Commercial Practicability of Electric Traction by Surface Contact	1904
	Cheap Power Supply by Municipalities	1907
	Advantages of Continuous Records of Cost and of Steam Consumption	1910
	Purchase of Fuel	1911
	Presidential Address	1913

Author.	Title.	Date.
Sillar, A. R.	Free Wiring and Supply on the Prepayment System	1905
Sinclair, Councillor.	Load Factor: Its Effect upon an Electricity Station	1905
	Cheap Units	1909
Smith, Alderman, J.P.	Some Statistics of Electrical Supply	1903
Snell, Sir J. F. C.	Generation of Steam	1897
	Single *versus* Multiple Generating Stations	1898
	Condensers for Electric Lighting and Power Stations	1899
	The Relative Advantages of Two and Three Wire Distribution	1902
	Presidential Address	1903
	Relative Economies of Electric Supply from Small Local Stations and from Power Companies	1906
Steinitz, J. J.	Generation of Steam	1896
Stewart, J. E.	Electric Traction	1898
Stewart, C. L. E.	Low Tension Continuous Current Switchgear	1903
Taite, C. D.	Street Lighting by Electricity	1897
	Notes on the Distribution of Electricity	1899
Talbot, H.	Presidential Address	1908
Taylor, A. M.	Alternating Current Accumulator Sub-Stations	1908
Tittensor, W. H.	The Equitable Allocation of Costs in Combined Lighting and Traction Stations	1901
Vesey Brown, C. S.	Electricity Works for Small Towns	1900
Vignoles, W. A.	The Efficiency of Steam Plant	1906
	The Commercial Development of Electrical Supply in Towns of Moderate Size	1914
Watson, S. J.	The Supply of Power to Tramways from small Stations	1906
	Cheapening of the Cost of Mains and Services	1910
	Automatic Pressure Regulations	1912
Watson & Mitchell	Electric Automobiles	1913
Wightman, Bailie.	The Experiences of a Convener in the Establishment of an Electricity Undertaking	1908

Author.	Title.	Date.
WILKINSON, G.	The Distribution of Electricity in Scattered Areas - - - - - -	1900
	Live Steam Heated Feed Water, its Effect on the Output and Efficiency of Steam Boilers - - - - -	1906
	Advantages of Continuous Records of Costs and of Steam Consumption -	1910
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WILMSHURST, T. P.	Electric Meters - - - - - -	1899
	Do. Motors - - - - - -	1900
	Presidential Address - - - -	1904
WORDINGHAM, C. H.	The Control by Municipal Authorities of Consuming Devices, and the Wiring connecting them to the Mains - -	1896
	Presidential Address - - - -	1897
	On the Necessity of Uniformity in Plant and Apparatus - - - - -	1898
	Maintaining Certain Portions of Electrical Distribution Systems at Earth Potential - - - - - -	1900
WRIGHT, A.	Presidential Address - - - -	1896
YEAMAN, C. H.	Depreciation and Reserves for Antiquation and Obsolescence, from an Engineering Standpoint - - -	1907

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Tramway Equipments
Petrol Electric Cars
Electric Motors
Complete Power Equipment for Industrial purposes
Transformers
Mining and Industrial Switchboards.
Circuit Breakers
Motor Control Panels
Starters
Controllers
Brake Magnets
Meters and Instruments
Metal Filament Lamps
Electric Fans
Electric Heating and Cooking Utensils
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PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION,

HELD AT THE INSTITUTION OF ELECTRICAL ENGINEERS, LONDON,

ON THURSDAY & FRIDAY, JUNE 17th & 18th, 1915.

REPORTED BY ARRANGEMENT WITH "ELECTRICAL ENGINEERING."

The Association is not as a body responsible for the views expressed by authors and speakers.

The Chairman (Mr. A. C. Cramb, Acting-President), in opening the proceedings, said that when they assembled in Birmingham last summer for the 1914 Convention they little thought that within a few weeks this country would be engaged in a terrible war. Unfortunately that was the case, and for the last nine months their thoughts had been occupied mainly with that subject, and it was inevitable that their energies must be, to a very considerable extent, occupied with carrying the war to a successful conclusion. The war had also some effect on the work of the Association. The President, Major Richardson, was called up for active

service early in the autumn, and, as it was evident that he would not be able to take part in the deliberations of the Council during the war, the Council had appointed the speaker as Acting-President in Major Richardson's absence. At the end of last year, when it became evident that the war would not be over by the summer, the Council had to consider what course should be adopted with regard to holding the Annual Summer Convention. After careful consideration it was decided that as by the By-laws of the Association they must have an Annual Meeting each year, a meeting should be held in London, but that all social engagements and visits on this occasion should be omitted, and, further, that the usual invitations should not be issued. He felt sure that this decision would meet with the approval of the meeting under the circumstances. The co-opted members of the Electric Vehicle Committee, and of the Development Committee, had been invited to take part in the discussions, and he took that opportunity on behalf of the Association, of thanking those gentlemen for so kindly taking part in the work of these two Committees, and giving their valuable time and experience to furthering the objects for which the Committees had been established.

The Chairman then called upon Mr. Roles, of Bradford, and Mr. Blackman, of Sunderland, to give a brief synopsis of their paper on the practical result of the Point Five Tariff.

Mr. A. S. Blackman (Chief Electrical Engineer, Sunderland) remarked that it was known that a criticism which would be made upon the adoption of a Point Five Tariff was likely to be that it had resulted in such a great reduction in the average price per unit. So far as he was personally concerned, it had not been his ambition to sell electricity exceedingly cheaply; it had been very largely a question of either reducing the rates or else losing the business to competitive illuminants and methods of heating. He quite appreciated that in industrial towns, such as Bradford and Sunderland, the conditions were

radically different to those in towns farther south, which were very largely dependent upon the private house load. He had before him a rough estimate of the cost of supplying the house load in Sunderland. These figures were based upon existing plant, which carried with it very heavy capital charges in comparison with what could be done in extensions to-day, so that if he could make out a case under existing conditions, he had a very good case indeed when it came to future extensions. The annual charges for interest and sinking fund upon the works plant in Sunderland amounted to £1 9s. 2d. per kw. per annum, and, taking a diversity factor of 20, this gave an annual charge of 1s. 5½d. for works plant to meet this domestic load. Coming to extra high tension feeders and sub-station equipment, this worked out to 11s. 7d., and, taking a diversity factor of ten, this gave 1s. 2d. per annum. With regard to low tension feeders and networks, which matter he had gone into very carefully by putting demand indicators in pits controlling certain areas, he took a diversity factor of 5, which gave 10s. 4d. per kw. That was the heaviest item and the total came to 12s. 11d. annual charges per kw. On an 18 per cent. load factor, electricity was at present being turned out at 0·15d. per unit, and this gave a total cost per unit of 0·247d., or, say, one farthing. So far from considering that he was on his defence in making out a good case in supplying at ½d. per unit, he was absolutely convinced that a ½d. was no good in the northern towns, at any rate for the heating load. It was all right for cooking, but for heating it was too expensive, and in the development of the Point Five Tariff there were two alternatives. One would be to keep the fixed charge as at present, and supply, in the case of a £40 a year house, the first three thousand units per annum at ½d., and all additional units at ¼d. The other alternative would be to give the consumer the option of paying a higher fixed charge and supplying the whole of the units at ¼d. It would be a matter for consideration in the future as to which of these two methods should be adopted, or some modification of them. So far as he was concerned, that was likely to be the trend of events.

The Practical Result of the Point Five Tariff.

By ALFRED S. BLACKMAN.
(*Chief Electrical Engineer, Sunderland*)

AND

THOS. ROLES.
(*Chief Electrical Engineer, Bradford*).

IT was originally intended that this Report upon experience gained in the working and application of the Point Five Tariff should, with the assistance of our fellow-members of "The Point Fives" Association, have summarized and presented more particulars than are now available. Owing, however, to shortage of staff and other matters arising out of the war, which handicapped the writers in circulating the question forms until a late date, and similarly prevented the completion and return of the forms, the details showing the results of the working of the tariff are not as complete as could be desired. The whole of the available returns are, however, tabulated, and appear at the end of the Report.

The following is a list, in chronological order, of the Undertakings which have adopted the Point Five Tariff,

together with the dates upon which the same was put into force :

Metropolitan Borough of Poplar	February, 1909.
County Borough of Southampton	March, 1910.
Borough of Luton	June, 1910.
City of Bradford	July, 1910.
County Borough of Sunderland	January, 1912.
Urban District Council of Barnes	April, 1912.
Metropolitan Borough of St. Marylebone	May, 1912.
City of York	September, 1912.
City of Carlisle	October, 1912.
Borough of Wrexham	March, 1913.
Borough of Accrington	April, 1913.
City of Sheffield	April, 1913.
County Borough of West Hartlepool	April, 1913.
County Borough of West Ham	June, 1913.
County Borough of Wolverhampton	June, 1913.
Urban District Council of Ilford	January, 1914.
County Borough of Blackpool	April, 1914.
City of Wakefield	April, 1914.
City of Worcester	June, 1914.
County Borough of Ipswich	July, 1914.
City of Leeds	January, 1915.
City of Chester	1915.

The majority, if not all, of the earlier Undertakings to adopt the Point Five Tariff did so as a result of independently coming to the conclusion that no substantial progress could be made in the supply of electricity for heating and cooking purposes in their areas at any rate exceeding one-halfpenny per unit. Although the investigations into the practicability of adopting such a tariff were conducted quite separately, the decision to put a Point Five Tariff into force in the towns concerned was come to at much about the same time.

To the Electricity Undertaking of the Metropolitan Borough of Poplar belongs the honour of being the first Electricity Supply Authority to adopt such a tariff, and although the same was in operation in February, 1909, this fact was not generally known until the formation of "The Point Fives" Association. The fixed charge at Poplar is varied in the case of the different premises supplied in accordance with the number of kilowatts installed for lighting, heating, cooking, and other purposes, and includes

a service charge and charges for the hire of wiring and consuming devices in cases where the two last mentioned items are supplied by the Undertaking on the hire system.

Southampton, the second town to adopt a Point Five Tariff, makes the granting of a halfpenny rate for heating and cooking purposes conditional upon the consumer installing a certain minimum number of lights charged for at ordinary lighting rates.

Luton, the next town to institute a Point Five Tariff, supplies current for heating and cooking purposes at a flat rate of one-halfpenny per unit without any fixed charge or conditions as to lights being installed on the premises supplied.

Bradford, the fourth town on the list, decided to confine its Point Five Tariff to domestic premises, and to base it on the "Norwich" or Rateable Value system of charging which, with a secondary charge of one penny per unit, had already proved its utility in a number of towns; and practically the whole of the Undertakings which have since become converts to the Point Five principle have adopted this system.

So far as the writers are aware, the two methods cited above of arriving at the fixed charge (where made) are the only ones which have been adopted up to the present in connection with Point Five Tariffs, and the difference between these methods is but one of convenience in the working of the tariff, the fixed charge per kilowatt being more strictly correct in individual cases, whereas the apportionment upon the size of the house is an average result which has been found to be a sufficiently close estimate for all practical purposes, and to possess the great advantage of uniformity and simplicity in application.

It should be recognised that the rateable value basis is only made use of as a means which is ready to hand of

determining the fixed charge approximately in accordance with the electricity consuming capacities of the premises supplied, and any other readily available basis might be adopted, as, for instance, the cubical capacity of the premises or the total floor area. As will be inferred from what has previously been stated this method of charging was not evolved in connection with Point Five Tariffs, but was initiated and put into use by Mr. F. M. Long, of Norwich, over eight years ago. Mr. Long, however, has not yet adopted a price of one-halfpenny per unit, the Norwich unit charge being something above this.

In most towns in which a Point Five Tariff, based on the Rateable Value system, has been instituted, the rate is restricted to the supply of electricity to private houses, as this method of determining the fixed charge does not so readily lend itself to the more widely varying conditions of other classes of supply. The percentage of the net rateable value decided upon varies in different towns, being usually between 10 per cent. and 15 per cent. per annum, the amount generally being apportioned between the four quarters of the year, sometimes equally and sometimes in approximate proportion to the lighting hours, as, for instance, one-third for each of the two winter quarters and one-sixth for each of the two summer quarters. In at least one case (Sunderland) the percentage is varied between 10 per cent. for a house rated at £30 to 15 per cent. for a house rated at £70 and upwards, the reason for this being that a large house generally furnishes a worse load factor than a small one.

For the purpose of reviewing Point Five Tariffs generally it is a matter of regret that both writers have obtained their experience under the Rateable Value system, as the results herein recorded for Bradford and Sunderland would, no doubt, have been different had a Point Five Tariff under some other method of charging been adopted. The writers fully recognise that the Rateable Value system has its disadvantages as well as its advantages, and any success which has been attained in Bradford and Sunderland is,

in their opinion, due to the fact that under the conditions prevailing in these towns the advantages considerably outweigh the disadvantages. Of course, it does not necessarily follow that the system would be equally successful in other towns.

It is hoped that members of " The Point Fives " Association who are not working on the Rateable Value system will in the course of the discussion give details of the results which have accrued from the operation of their own particular methods of charging.

It should be noted that in the case of both Bradford and Sunderland the tariff adopted has been left to justify itself, and that although electric heaters and cookers have been shown at various small exhibitions, no scheme of hiring out heating and cooking apparatus is in existence in either town. It can, therefore, the writers think be very reasonably claimed that had such hiring schemes been inaugurated, and energetic and sustained publicity campaigns been instituted by the two Undertakings under their control, the results shown in this Report would have been still more favourable.

In the application of a Point Five Tariff, based upon Rateable Values, a discretion should be exercised in favour of the consumer who, in consequence of living in a house with an abnormal amount of ground attached to it, is rated out of proportion to the size of the house. So far as Sunderland is concerned no difficulty whatever has arisen in dealing with these cases; the Rating Department have simply been asked to say how much of the Rateable Value could properly be apportioned to the excess of ground over and above a normal allowance, and such amount deducted from the Rateable Value in fixing the charge under the tariff. In Bradford, on the other hand, the Rating Authorities, when approached, have only deducted a sum from the total equal to the rateable value of the surrounding land as it would be assessed if used for agricultural purposes, and state that they cannot say what increased value can be put

upon the land by reason of its being attached to the house. It follows, therefore, that a reduction made on these lines is insufficient, and if cases arise in which this point has to be decided, the practice adopted will probably be to base the fixed charge on what is being paid for houses of similar size with a normal allowance of land.

A marked advantage of the Rateable Value basis is the facility with which an accurate estimate of a consumer's bill can be prepared. Once the fixed charge for a house has been ascertained, a wide error may be made in assuming the number of units that will be used, and the estimate still remain reasonably correct, as is shewn by the following example in which the fact of the number of units consumed proving to be 50 per cent. in excess of the number estimated, results in an increase of only 16 per cent. in the total amount of the account.

HOUSE OF £40 RATEABLE VALUE, AT, SAY, 11 PER CENT. PER ANNUM.

	£	s.	d.		£	s.	d.
Fixed charge - - -	4	8	0	Fixed charge - - -	4	8	0
1,000 units - - -	2	1	8	1,500 units - - -	3	2	6
Total - -	6	9	8	Total - -	7	10	6

This facility for estimating has been found in practice to be a very useful asset to the canvassers in towns where a cheap supply of gas has to be competed against.

It likewise follows that the importance of any error in metering is correspondingly lessened.

Numerous other advantages have attended the adoption of a Point Five Tariff based on the Rateable Value system amongst which the following may be cited :—

When charged under the ordinary flat rate for lighting purposes it was, as a rule, found that residential consumers only introduced electric light into the best rooms, leaving the servants' quarters, etc., which possess a better load

factor, illuminated by gas. The fact, however, that on the Rateable Value basis, once the fixed charge is assessed, all current required for lighting, as well as for heating and cooking purposes, is supplied at the low price of one-half-penny per unit, has in most cases induced private house consumers to light the whole of their premises electrically, with a consequent improvement in the load factor of the installations.

Further, carelessness on the part of members of households in leaving lights burning while rooms are not in use does not result in the amounts of the accounts being unduly inflated.

In addition to this, under a flat rate of charge the lighting of most houses using electricity compared unfavourably with that of houses illuminated by gas, especially where the mantles in the latter were kept in good condition. The reason for this was that, on the score of economy, lamps of only small candle-power were generally in use. The making of the fixed charge in a house of any given Rateable Value quite independent of the number and size of the lamps installed, coupled with the supply of current at a cheap rate, has resulted in consumers using lamps of considerably higher candle-power, thus obtaining an illumination at least equal to that of gas-lighted premises. As a matter of fact, it is now usually quite easy to determine whether or not a house is on the Point Five Tariff by the brilliancy of the light proceeding from the windows of premises taking a supply under this rate. It may, of course, be argued that the additional maximum demand caused by this increase of light must adversely affect the supply undertaking. Against this must be put the fact that, owing to the houses being almost invariably wired throughout, the diversity factor of the installations is higher, which tends greatly to increase the load factor of this class of supply.

No additional charges can be made against the increased amount of lighting on account of services or distribution

mains, as the cables used for these purposes are generally standardized to two or three sizes, and the cost of trenching, cutting away of walls, etc., is practically independent of the size of cable used. In many cases both mains and services were already in existence on the Point Five Tariff being adopted, and in a large number of other cases mains had previously been laid in front of the premises.

Taking this class of supply altogether, therefore, the additional expenses to the Undertaking consist of the cost of increasing the capacity of the generating plant—which can now be done at far cheaper rates than in the days when the flat rate for lighting purposes was decided upon—and the provision of extra feeder cables. No additional management charges can be debited against the extra lights, as whatever the size of the installation the cost of service inspection, meter reading, rendering of accounts, and general management of the Undertaking is practically the same.

It is, of course, possible that under Point Five Tariffs based on the Rateable Value system, the increased capital expenditure incurred on account of new plant and feeder cables rendered necessary owing to the improved illumination previously referred to, causes a reduction in the profits accruing to supply authorities from a number of consumers who have changed over from the old rates. As a result of their experience, however, the writers are firmly of opinion that any such reduction in profits from quite a limited number of consumers is soon far more than counter-balanced by the profits derived from the additional consumers gained by reason of the excellent advertisement obtained in consequence of the improved lighting.

In both Bradford and Sunderland it has been found that the majority of new domestic consumers adopt the rateable value tariff ; houses are, as a rule, wired from cellar to attic ; the domestic load factor has improved ; the illumination of rooms has in almost every case been considerably increased ;

and no complaints are now received as to the inefficiency of electric lighting as compared with lighting by means of gas.

Dealing with Point Five Tariffs generally, it may be mentioned that, prior to such tariffs being put into force, electricity was used for heating purposes by a number of consumers in the towns mentioned in this Report at prices varying from the ordinary lighting rates to one penny per unit, the heating medium usually being a one-kilowatt four-light radiator. Much dissatisfaction was, however, expressed at the amount of heat given off by radiators of this capacity and at the expense attached to their use; consequently their adoption was confined to enthusiasts or to situations in which it was difficult or impossible for a coal or gas fire to be fitted, as, for instance, where flues were non-existent. Since current has been supplied at one-halfpenny per unit, however, not only has the number of electric heaters increased to a tremendous extent, but the capacity of the individual heaters has also increased, so that fires taking three and four kilowatts are now quite common; in fact, in several Point Five towns the three-kilowatt radiator has become a standard. The result is that instead of electric radiators being used to warm the occupants of rooms by radiant heat, the air temperature of the rooms being but little affected, the temperature of the apartments is kept practically constant throughout, and the occupants are under no necessity to remain within the direct rays of the heaters.

From the point of view of the preparation of this Paper it is unfortunate that the Electricity Supply Undertakings under the management of the writers are both situated in industrial towns, so that the house supply load is not of the importance, nor can the detailed attention be paid to it, as in some areas where it is the chief source of revenue. As illustrating this point it may be mentioned that in Bradford the units sold to private houses are only 3 per cent. of the total sales, and in Sunderland 2·6 per cent., and this fact should be taken into consideration in reviewing

the figures that follow bearing on the growth of business under the Point Five Tariff in these towns. In the case of each Undertaking very full technical records have been kept, which enable the trend of events to be clearly determined.

BRADFORD RESULTS.

No better testimony as to the popularity of the Point Five Tariff in operation in Bradford can be furnished than by directing attention to the fact that at the 31st December last 1,298 private house consumers were connected to the supply, whereas prior to the introduction of this method of charging on the 1st July, 1910, the number of such consumers was but 511, representing the result of nearly twenty-one years' working. It will thus be seen that during the four and a half years the Point Five Tariff has been in force the number of domestic consumers has increased by 787, or over 150 per cent. Four hundred and three, or more than half, of these consumers, have elected to be charged on the special rate, the houses being in practically all cases electrically-lighted throughout.

Three hundred and eighty-three of the 511 private house consumers on the supply at the 30th June, 1910, have adopted the Point Five Tariff in place of the lighting flat rate of 4d. per unit under which they were previously charged. Owing to changes of tenancy and alterations in other conditions the comparison given below relates to only 138 of the consumers changed over, the periods covered being the year prior to the introduction of the Point Five Tariff and the year ended 31st December, 1914.

Load Factor.—Based on the total kilowatts installed the average load factor of the 138 consumers in question has increased from 3·38 per cent. to 4·34 per cent., equivalent to an increase of 28·4 per cent.

Units Sold for a Complete Year

Under old Tariff	93,880
,, Point Five Tariff	182,872
Average per house under old Tariff	680
,, ,, ,, ,, Point Five Tariff	1,325
Increase	94·9 per cent.

Revenue.

	£ s. d.
Total under old Tariff	1,566 0 0
,, ,, Point Five Tariff	1,358 0 0
Average per house under old Tariff	11 5 6
,, ,, ,, ,, Point Five Tariff	9 16 10
,, price under old Tariff	3·98d.
,, ,, ,, Point Five Tariff	1·78d.

The figures given above relative to the old tariff are inclusive of separate charges made for meter hire. Under the Point Five Tariff the rental of the meter is covered by the fixed charge. On this score the figures are therefore strictly comparable.

The following table gives details as to the number of units sold, revenue obtained, etc., in the case of consumers supplied under the flat rate of 4d. per unit and under the Point Five Tariff respectively, the comparison applying to all domestic consumers connected for the complete twelve months ended 31st December last :—

Tariff.	Number of Consumers.	Total units sold.	Average number of units per house.	Total revenue.	Average revenue per house.
4d.	340	124,742	367	£2,005	£5 18s. 0d.
·5d.	566	612,502	1,082	£4,312	£7 12s. 4d.

Diversity Factor —The particulars given below illustrate the effect the Point Five Tariff has had on the diversity factor, the periods compared being the twelve months ended

30th June, 1910, and the twelve months ended 31st December, 1914.

Twelve months ended.	Maximum load on L.T. feeders for residential areas only.	Total kilowatts installed in private houses.	Diversity factor.
30th June, 1910.	158 kw.	420 kw.	2·65
31st December, 1914.	290 kw.	853 kw.*	2·94

* *This is the total for which application has been made. It has, however, been found since the introduction of the Point Five Tariff that heating and cooking apparatus, particularly the former, has been connected in private houses to a considerable extent without the Electricity Department being notified. Consequently the figure given is very much on the low side, and this naturally reflects on the Diversity factor, which is undoubtedly greater than 2·94 as stated.*

In conjunction with the above table, it may be mentioned that the 420 kilowatts of consuming devices installed at the 30th June, 1910, in private houses in the residential areas dealt with were almost exclusively for lighting purposes. As at that date the number of consumers affected was 233, an average of 1·8 kilowatts per house is obtained.

At the 31st December, 1914, the consuming devices in connection with the installations in these particular areas had increased to 853 kilowatts and the number of consumers to 367, giving an average of 2·32 kilowatts per house. Of the total of 853 kilowatts connected, 545 were for lighting purposes and 308 for heating and cooking purposes, the average per house being 1·48 and 0·84 kilowatts respectively.

As will be seen by referring to Table No. 1 at the end of this Report, the annual percentage of the rateable value debited to a consumer in Bradford adopting the Point Five Tariff is 15, and in this connection it may be stated that based on the rateable values obtaining in the city it is estimated that such percentage, coupled with a charge of one halfpenny per unit, brings in a revenue equivalent to what would be earned for an average supply of current for

lighting purposes at a flat rate of 4d. per unit. All energy required for heating and cooking purposes is under these conditions obtained at the halfpenny rate.

Although in Bradford domestic consumers have not been approached individually for the purpose of explaining the advantages they would enjoy by changing over from the flat rate to the Point Five Tariff, more than half of such consumers have elected to be charged on the latter system, and have introduced electric heating or cooking apparatus. This is all the more remarkable when it is borne in mind that no general attempt has been made to induce consumers to install heating and cooking apparatus, the staff of the business-development department having been fully occupied in dealing with power supplies.

In addition to this, an agreement has been in existence between the Gas and Electricity Departments that in thoroughfares in which electricity mains are already laid the Electricity Department's canvassers shall not call upon gas consumers with a view to persuading them to take an electricity supply. Furthermore, the Gas Department have been exceedingly active during the past few years in advocating the use of gas for heating and cooking purposes.

The following extract from a letter received by one of the writers from Mr. P. Collinson, the Honorary Secretary of the Bradford Branch of the Electrical Contractors' Association (Incorporated), is of interest as expressing the views of the Bradford Wiring Contractors on the Point Five Tariff in operation in that city :—

> " The Domestic Tariff is one that is popular among your consumers in that it is quite simple and easily understood ; in this it differs materially from your Maximum Demand System of charging, which I find to be quite beyond the grasp of the average lay mind and which further is looked upon with some degree of suspicion.

By enabling one set of wires to be used for both heating and lighting, the Domestic Tariff simplifies the wiring of a house and, therefore, reduces the initial cost of the installation, and by so doing tends to popularise the use of electricity. In addition to this I find that extensions of the wiring are easier and not so costly as when the house is wired in duplicate for both heating and lighting.

"I find that where the Domestic Tariff is in operation it is much easier to persuade the user to extend both his lighting and heating installation than is the case when the user takes his energy at the old Flat Rate; the argument that the additional load will only add so much electricity at ½d. per unit to his bill usually proves irresistible. The large increase in the number of radiators installed in Bradford during the past few years is undoubtedly a direct result of the Domestic Tariff, and I believe that it is only under this system of charging that electric cooking will make appreciable headway.

"Looking at the Domestic Tariff from a Contractor's point of view, I am satisfied that it is a system of charging which makes for increased business, and as it appears to give satisfaction to the user, it has my emphatic approval, coupled with the hope that the principle may, at an early date, be extended to those of your consumers who are occupiers of shop, warehouse, and other business premises, and who are at the moment excluded from the scope of this tariff.

"In conclusion I may add that the opinions expressed in this letter are not my personal opinions only, but are the opinions of the bulk of my confreres in this city."

SUNDERLAND RESULTS.

At the introduction of the Point Five Tariff there were 337 private houses connected to the supply, the majority partially lighted only, as the result of sixteen years' working. Since the tariff was introduced upon the 1st of January, 1912, three years' working has resulted in 162 more private houses being connected; 100 of these elected to be put on the Point Five Tariff and are lighted throughout, and 62 upon a flat rate of 3·6d. per unit.

Of the 337 houses that were on the supply at the 1st January, 1912, 105 have changed over from a flat rate of 3·6d.

per unit to the Point Five Tariff, and of these 105 houses 87 have, owing to there being no change of tenancy, been taken for the following comparison, the periods being the year preceding and the year following the adoption of the Point Five Tariff:

LOAD FACTOR.—The average of consumers' load factor on kilowatts installed has been increased from 2·44 per cent. to 4·05 per cent., an increase of 66 per cent.

UNITS SOLD FOR A COMPLETE YEAR.

Under old Tariff	44,827
,, Point Five Tariff	93,327
Average per house under old Tariff	512 (354)
,, ,, ,, ,, Point Five Tariff	1,073
Increase	109·5% (203·1%)

REVENUE.

	£ s. d.	
Total under old Tariff	672 0 0	
,, ,, Point Five Tariff	616 0 0	
Average per house under old Tariff	7 14 5	(£5 5s. 9d.)
,, ,, ,, ,, Point Five Tariff	7 1 7	
,, price under old Tariff	3·6d.	
,, ,, ,, Point Five Tariff	1·58d.	

For the purposes of comparison it must be remembered that the units and money values underlined refer almost entirely to carbon lamp conditions, and our experience with pure lighting installations that have remained upon our mains unaltered over a term of years, save for the transition from carbon to metal filament lamps, shows that for purposes of comparison under modern conditions the figures in brackets should be substituted for those underlined, and this has been done for the purpose of the following comparison.

The comparative results obtained from alternative tariffs for all private houses connected for the year ended 31st December, 1914, are as follows :—

Tariff.	Number of Consumers.	Total units sold.	Average number of units per house.	Total revenue.	Average revenue per house.
				£	£ s. d.
3·6d.	212	75,032	354	1,121	5 5 9
·5d.	286	298,563	1,044	1,803	6 6 11

The average size of the houses in these two groups is about the same, so that the heavier unit consumption under the Point Five Tariff is in no way attributable to larger houses.

Diversity Factor.—The following table shows the effect of the Point Five Tariff upon the diversity factor, the periods being " A," just before the introduction of the tariff, viz., December, 1911, and " B," December, 1914, and the maximum load figures being taken at the time of the peak load at the low-tension bus-bars.

	Maximum load on L.T. feeders for residential areas only.	Total kilowatts installed in private houses.	Diversity factor.
" A " - -	141 kw.	461 kw.	3·25
" B " - -	227 kw.	1,152 kw.	5·00

It will be noted that the results shown in the two foregoing tables as between the 3·6d. and the Point Five Tariff, and as between the periods " A " and " B " are very considerable, and as touching the current selling propensities of heating and cooking apparatus it will be useful to point out that

these results have been obtained by the following consuming devices :—

"A"	461 kw. installed upon consumers' premises, almost exclusively for lighting— Average per consumer	=	1·36 kw.
"B"	650 kw. installed upon consumers' premises for lighting - - - Average per consumer	=	1·30 kw.
	502 kw. installed upon consumers' premises for heating and cooking - Average per consumer	=	1·009 kw.

The writers' thanks are due and are hereby tendered to the members of "The Point Fives" Association who have, during a difficult time, furnished the information given in the Tables at the end of this Report, a study of which Tables will be interesting and instructive. An outstanding feature of these returns is the conspicuous success that has been achieved by those Undertakings hiring out heating and cooking apparatus.

ON.	SUNEXHAM.	YORK.
	1s. 9d	2s. 3d. 2s. 3d.
o.	Jan ch, 1913.	September, 1912.
1	£15 to £30 ra net assess- £30 to £4 of house. £50, 12%; £60 to £7c 15%.	10% net rateable value + 1d. per unit up to amount equal 75% fixed charge, ½d. per unit after.
4	All accounts — installed se sumer. P able value kw. install known to l out.	By investigation on the comparison between users of lighting only and lighting, heating, and cooking.
5	e had no oc- as yet, but modify it in se of stables utlying work-	When over half-an-acre of land a rebate may be given.
6	Land apport nate the rent, rateable rtion the as- house, any ent on that proportion and deduct value. from whole sment.	As above to meet the very few, if any, exceptional cases.

TABLE No. 1.

	Accrington	Barnet	Blackpool	Bradford	Carlisle.	Ilford.	Ipswich.	Leeds.	Luton.	St. Marylebone.	Sheffield.	Southampton.	Sunderland	West Ham.	Wolverhampton	Worcester.	Wrexham.	York.
2 Standard gas per 1,000 cubic feet [illegible] purposes																		
Lighting	2s. 10d., less 2½% discount.	Brentford Co., 2s. 4d.; Richmond Co., 2s. 10d.	2s.	2s. 1d	2s.	2s. 8d.	2s. 4d.	2s. 2d.	2s. 2d.	2s. 6d. before War; 2s. 8d. December, 1914, to March, 1915; 3s. from April, 1915.	1s. 3d.	2s. 6d.	1s. 9d. to 1s. 3d.	3s.	2s. 6d.	2s. 3d.	2s. 3d.	2s. 3d.
Heating and cooking	2s. 10d. less 2½% discount	Brentford Co., 2s. 4d.; Richmond Co., 2s. 10d.	2s.	2s. 1d.	2s.	2s. 8d., less discount	2s. 4d.	2s. 2d.	2s. 2d.	2s. 6d. before War, 2s. 8d. December, 1914, to March, 1915; 3s. from April, 1915.	1s 3d.	2s. 6d.	1s. 9d. to 1s. 3d.	3s.	2s. 6d.	2s. 3d.	2s	2s. 3d.
3 Introduction of [illegible] tariff	April, 1913.	April, 1912	April, 1914.	July, 1910.	October, 1912	January, 1914.	July, 1914.	January, 1915.	July, 1910	1912 for residences.	April, 1913	April, 1910.	January, 1912.	June, 1913.	June, 1913	June, 1911	March, 1913.	September, 1912.
[illegible] standing charge	5% per annum on net rateable value of house occupied.	10% per annum on rateable value payable quarterly.	12½% on rental value of residence for assessment purposes. Houses rated at over £100 charged on 10%.	15 .. per annum on rateable value of property occupied.	12½% of net rateable value.	12½% per annum on rateable value.	12½% on rateable value	Not exceeding £15 rateable value 30s; £15 to £50 rateable value increases in steps of 10s. per £5, £50 and over, 10% on rateable value.	None.	Residences at £18 13s. 4d per calculated maximum demand of lighting. Calculated maximum demands equals 70% of watts installed, less convenience lights.	10% on rateable value	No rental charge.	£15 to £30 rateable value, 10%; £30 to £40, 11%; £40 to £50, 12%; £50 to £60, 13%; £60 to £70, 14%; over £70, 15%.	Lighting—£10 per annum per kw. installed (minimum £2 per annum); heating, cooking, etc., 10s. per annum per kw. installed for first two kw., 6s. 8d. per annum per kw. above (minimum 10s. per annum).	(1) 15% of the rateable value. (2) A calculated amount depending upon demand and diversity factor.	15% on rateable value rendered 4% for quarters ending December and March, and 24% for quarters ending June and September.	15% on net assessment of house	10% net rateable value + 1d. per unit up to amount equal 75% fixed charge, 3d. per unit after.
4 How was basis of fixed charge arrived at?	—	After analysis of accounts of over 3,000 consumers supplied at rate of 3½d. per B.T.U.	After analysis of accounts of 400 to 500 residential consumers.	After analysis of accounts of all residential consumers to ascertain fixed charge + 3d. per unit which would give same return on lighting supply as flat rate of 4d.	—	Percentage fixed at a figure which would produce as nearly as possible the same revenue as would be received if current were taken for lighting only at 3½d. per unit, so that all extra current would be at 5d.	After analysis of accounts of large number of consumers to ascertain the fixed charge + 4d. per unit which would give same return on lighting supply as flat rate of 4d.	By comparison with what was paid under flat rate of 3½d	—	Old rate £14 per kw. of maximum demand, and 1d per unit up to units equal to 25% of kw. charge, then ½d. until units value equal kw. charge, 4d. per unit after. Difference in money value between 1d 2d., and ½d units added to kw. charge and all units charged at ½d.	—	—	All accounts tabulated, and kw. installed set against each consumer. Percentage of rateable value fixed according to kw installed in those houses known to be lighted throughout.	Arrived at in regard to cost of supply and estimated allowance for diversity of cooking and heating.	(1) On the average rate given by 200 consumers' accounts. (2) By straight-forward calculation.	All accounts tabulated, rate then fixed to ensure revenue near that previously received from lighting alone.	—	By investigation on the comparison between users of lighting only and lighting, heating and cooking.
5 Is [illegible] fixed charge is dependent on rateable value of premises do you modify same in special cases such as those of houses with extensive grounds or large houses with low rateable values?	Not at present	Not at present.	No modifications. Houses with large gardens are very few here.	Only in one case.	No.	No.	Have not had to do so yet, but will do so when necessary	Not up to present, except where ground is rated as agricultural land.	—	Not dependent on rateable value.	—	—	Yes.	—	Yes	Not as yet. Matter of allowance for extensive grounds must soon be considered.	We have had no occasion as yet, but we do modify it in the case of stables and outlying workshops.	When over half-an-acre of land a rebate may be given.
6 If modifications are made by what method do you arrive at the fixed charge in such special cases?	—	—	—	No definite method adopted	—	—	Have not yet decided—probably some percentage rebate per acre above a certain area.		—		—	—	Land apportioned according to rateable value and size of house, any surplus deducted proportionate with rateable value.	—	By excluding an estimated rateable value of extra land, etc., from rateable value of the whole.	—	We estimate the rent, proportion the assessment on that basis, and deduct result from whole assessment.	As above to meet the very few, if any, exceptional cases.

SUNDERLAND.	WORCESTER.
11·46%	Not possible to state accurately as combined supply given on mains for power. Diminished demands through war conditions also make it impossible to submit figures.
18·76%	
2·44%	4·68%
4·05%	5·59%

efore ption of Tariff.	*Under present conditions.*	*Before adoption of ·5 Tariff.*	*Under present conditions.*
0·85	227·34	—	—
1·213	1152·529	86·1	213
3·3	5·1	—	—

s. 1 and 2, figures given being 13·5% and
EXHAM replied to Questions Nos. 1 and 2.

TABLE No. 2.

	Bradford.		St. Marylebone.		Sunderland.		Worcester.	
Load Factors.								
1. Load factor on networks supplying residential neighbourhoods at the initiation of the ·5 Tariff.	9·6%		16·9%		11·46%		Not possible to state accurately as combined supply given on mains for power. Diminished demands through war conditions also make it impossible to submit figures.	
2. Load factor on networks supplying residential neighbourhoods for the last completed year. Formula— Number of units sold × 100 / Maximum simultaneous load on feeders in kw. × 8,760* = % * Hours of supply period.	13·01%		21·4%		18·76%			
To Show Improved Load Factor of Consumers who have Changed over to the ·5 Tariff from some other Tariff.								
3. Average load factor of such consumers before changing over ..	3·377%		This question is not answered, for the information would be most misleading, as load factor of each consumer would vary with the loading of the apparatus installed. In fact with quick heating apparatus the load factor would go down in every case, and yet the load factor on the Station and feeders would be considerably improved owing to huge diversity factor.		2·44%		4·68%	
4. Average load factor of same consumers for last completed year .. Formula— Number of units sold × 100 / Total kw. of consuming devices installed × 8,760 = %	4·339%				4·05%		5·59%	
Effect of ·5 Tariff on the Diversity Factor.	*Before adoption of ·5 Tariff.*	*Under present conditions.*	*Before adoption of ·5 Tariff.*	*Under present conditions.*	*Before adoption of ·5 Tariff.*	*Under present conditions.*	*Before adoption of ·5 Tariff.*	*Under present conditions.*
5. Maximum load in kw. on feeders supplying networks in residential neighbourhoods. (Amperes × voltage of consumers' supply.)	158	290	8,300	10,500	140·85	227·34	—	—
			These figures apply to the total supply, most of which is for residential purposes.					
6. Total kw. of all consuming devices installed in private houses on above networks.	420	853	20,600	28,300	461·213	1152·529	86·1	213
7. Diversity factor	2·65	2·94	2·5	2·7	3·3	5·1	—	—
			The diversity factor would show up much more for year ended 1915 owing to big heating and cooking connections.					

Barnes replied to Questions Nos. 3 and 4, figures given being 5·20% and 3·50% respectively. Blackpool replied to Questions Nos. 1 and 2, figures given being 13·5% and 15·5% respectively. Wolverhampton replied to Questions Nos. 3 and 4, figures given being 3·2% and 6·2% respectively. Wrexham replied to Questions Nos. 1 and 2, figures given being 17·3% and 20·9% respectively.

HAM.	YORK.	
	105	
	105	
Under ·5 Tariff.	*Under old Tariff.*	*Under ·5 Tariff.*
11,582	31,920	107,344
£ s. d.	£ s. d.	£ s. d.
48 2 7	465 10 0	662 3 9
2,895	304	1,022
£ s. d.	£ s. d.	£ s. d.
12 0 8	4 9 0	6 6 6
·99d.	3·5d.	1·48d.
	31st March, 1915.	
Under ·5 Tariff.	*Under alternative Tariff.*	*Under ·5 Tariff.*
45	302	105
44,383	91,800	107,344
986	304	1,022
£ s. d.	£ s. d.	£ s. d.
300 11 6	1,338 15 0	662 3 9
6 13 7	4 8 8	6 6 0

TABLE No. 3.

	Blackpool.		Bradford.		Carlisle.		Ilford.		Luton.		St. Marylebone.		Sunderland.		Wolverhampton.		Worcester.		Wrexham.		York.	
To Show Effect of Income Derived from ·5 Consumers.																						
1 Number of houses changed over to date from some other tariff to ·5 Tariff.	45		383		14		230 (Approx.)		—		—		105		307		30		11		105	
2. Number of houses changed over in connection with which following comparison can be made.	12		138		14		Figures relate to 30 representative consumers with R.V.s from £19 to £56.		—		20 typical cases have been taken for this purpose.		87		About 150, but results given below only apply to 50.		30		4		105	
Results of one complete year's working.	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.* Year ended Mar., 1910. 51 Houses.	*Under ·5 Tariff.* Year ended Mar., 1915. 110 Houses.	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*	*Under old Tariff.*	*Under ·5 Tariff.*
3. Total units	15,122	51,369	93,880	182,872	8,310	24,233	12,599	26,218	36,356	147,914	20,100	175,000	44,827	93,327	16,789	148,118	15,126	31,621	4,783	11,582	31,020	107,344
4. Total revenue	£ s. d. 136 2 2	£ s. d. 198 14 7	£ s. d. 1,556 1 3	£ s. d. 1,358 3 8	£ s. d. 108 6 11	£ s. d. 134 0 8	£ s. d. 174 6 9½	£ s. d. 182 9 0½	£ s. d. 390 3 5	£ s. d. 730 17 0	£ s. d. 355 0 0	£ s. d. 732 0 0	£ s. d. 672 8 1	£ s. d. 616 2 4	£ s. d. 238 0 0	£ s. d. 547 0 0	£ s. d. 196 15 2	£ s. d. 195 3 8	£ s. d. 41 2 10	£ s. d. 48 2 7	£ s. d. 465 10 0	£ s. d. 662 3 9
5. Average units per house	1,260	4,280	680	1,325	595	1,731	420	874	713	1,344	1,005	8,750	512	1,073	336	2,962	504·2	1054·3	1,196	2,895	304	1,022
6. Average revenue per house	£ s. d. 11 6 10	£ s. d. 16 11 2	£ s. d. 11 5 6	£ s. d. 9 16 10	£ s. d. 7 14 0	£ s. d. 9 10 0	£ s. d. 5 9 6	£ s. d. 6 1 7	£ s. d. 7 13 0	£ s. d. 6 12 10	£ s. d. 17 15 0	£ s. d. 36 12 0	£ s. d. 7 14 5	£ s. d. 7 1 7	£ s. d. 4 14 0	£ s. d. 11 0 0	£ s. d. 6 11 2	£ s. d. 6 10 1	£ s. d. 10 5 8½	£ s. d. 12 0 8	£ s. d. 4 9 0	£ s. d. 6 6 6
7 Average price per unit	2·16d.	0·9d.	3·978d.	1·782d.	3·1d.	1·34d.	3·3d.	1·7d.	2·57d.*	1·18d.*	4·25d.	·1·006d.	3·6d.	1·58d.	4d.	·886d.	3·12d.	1·48d.	2·06d.	·99d.	3·5d.	1·48d.
									* Price for lighting considerably reduced since 1910.													
Comparison of Present Supplies.																						
8 Year ended	31st March, 1915.		31st December, 1914.		31st March, 1915.		—		31st March, 1915.		—		31st December, 1914.		31st March, 1915.		31st March, 1915. (Nine months only.)		—		31st March, 1915	
	Under alternative Tariff.	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff.*	*Under alternative Tariff.*	*Under ·5 Tariff*
9. Number of private houses supplied for a complete year.	2,858	12	340	566	47	60			320	110			212	286			301	30	43	45	302	105
10. Total units supplied to such houses for a complete year.	2,000,000 (Approx.)	51,000 (Approx.)	124,742	612,502	15,388	227,159	These figures cannot be got out owing to depletion of staff.		81,863	147,914	These figures cannot be got out owing to depletion of staff.		75,032	298,563	*See* example for 50 consumers above.		77,020	31,621	24,234	44,383	91,800	107,344
11. Average units supplied per house for a complete year.	700	4,280	367	1,082	325	3,786			256	1,344			354	1,044			258	1,054·3	563	986	304	1,022
12. Total revenue from such houses for a complete year.	£ 25,000	£ 198	£ s. d. 2,005 1 2	£ s. d. 4,311 18 11	£ s. d. 256 9 0	£ s. d. 709 0 7			£ s. d. 1,006 5 4	£ s. d. 730 17 0			£ s. d. 1,120 18 4	£ s. d. 1,803 6 1			£ s. d. 1,311 9 10	£ s. d. 195 3 8	£ s. d. 241 0 0	£ s. d. 300 11 6	£ s. d. 1,338 15 0	£ s. d. 662 3 9
13 Average revenue per house for a complete year.	£ s. d. 8 15 0	£ s. d. 16 11 0	5 18 0	7 12 4	5 13 0	11 16 0			3 2 10	6 12 10			5 5 9	6 6 11			4 7 1	6 10 1	5 12 1	6 13 7	4 8 8	6 6 0

Barnes replied to Questions Nos. 1 and 2, figures being 63 and 46 respectively; also to Question No. 9, number under alternative tariff being 3,274, and under ·5 tariff 46.
West Ham replied to Question No. 1, figure being given 22.

EST HAM.

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cooking con-
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erally. 100 in
l district.

Yes.

20%.

Yes.

20%.

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TABLE No. 1

	Accrington	Barnsley	Blackpool	Bournemouth	Carlisle	Ilford	Ilkeston	Luton	St. Marylebone	Southampton	Sunderland	West Ham	Wolverhampton	Worcester	Wrexham	York
1 Average number of units used per consumer, during a complete period of twelve months, by consumers having rateable values as follows									*Annual Charge.* £ / *Units*							
Exceeding £10 but not exceeding £20		160		138	378	Regret cannot separate. Average of all 5 consumers over 12 months gives average units 843, average price, 1·38d.			3 / 1,500		638		2,397	914	427	451
,, £20 ,, ,, £30		195	1,263	218	1,817		—	—	8 / 2,500		881		3,118	1,143	1,163	684
,, £30 ,, ,, £40		911	2,830	1,186	685		—	—	8 / 3,500		858		2,290	1,121	1,161	904
,, £40 ,, ,, £50		681	3,000	1,534	1,913		—	—	10 / 4,000	—	1,075		3,293	1,186	705	1,310
,, £50 ,, ,, £60		1,151	3,000	1,426	1,261		—	—	13 / 6,000	—	1,144		4,020	904	2,040	709
,, £60 ,, ,, £70		1,125	5,000	2,553	1,211		—	—	20 / 8,000	—	1,125		1,631	1,362	1,500	2,366
,, £70 ,, ,,		3,513	7,298	2,266	1,189		—	—	— / —	—	1,087		—	945	1,277	2,205
2 Standard sizes of service mains in use	4 and 7 wire.	4 and 7 wire.	025 to 05 sq. in.	7/14 and 19/16 and 3 and 4 025 sq. in.	19/16, 7/16 L.C.A.	7/16, 7, 18 and 7/20	7/18 smallest size; now using 7/16 for all residence work	7/18 and 7/16 service cable, two or three wire, depending on size of house.	025 and 05 sq. in. usual service.	7/16 for small houses and 7/14 for large houses	025, 05 and 075 sq. in.	Mostly from 01, to 035 sq. in.	022 × 022 × 022 sq. in. for D.C. 3 wire services. 4 core 12 sq. in. for 3 phase A.C. supply.	028 and 05 sq. in. L.T.C.	7/16 × 7/18 × 7/16 service mains.	05 × 025 × 05 sq. in. triple concentric.
3 Whether any difficulty experienced by increased load on mains due to heating and cooking purposes.	None up to present	A few isolated cases of difficulty in balancing.	Only in a few cases of old services	No	No difficulty so far.	No	No difficulty experienced by increased load due to heating and cooking	None. Up to 50 amps. of actual demand allowed on one side of system.	—	—	Several cooking consumers have been cause of expensive mains extensions		Yes	The difficulty is beginning, but not serious yet. Heating is fairly steady.	No.
4 Voltage of supply	240	210	200	230	230	230	—	250 D.C.	240 and 480. 3-wire D.C.	—	220	200 generally. 100 in central district.		100 and 200 A.C.	230	—
5. Do you hire out Cooking Apparatus?	No. Sell on three year's purchase, and sell outright	No	No. No power.	No.	Yes.	No.	No.	No.	Yes.	Yes	No.	Yes.	Yes.	No.	No.	Yes.
6 If so, what percentage does annual rental of apparatus bear to capital cost?	—	—	—	—	20%	—	—	—	10 to 35%	25 „	—	20%	Average of 15%	—	—	10%
Do you hire out Heating Apparatus?	No. Sell on three year's purchase, and sell outright	No	No. No power.	No.	Yes.	No.	No	No	Yes.	Yes	No.	Yes.	Yes.	No.	No.	Yes.
If so, what percentage does annual rental of apparatus bear to capital cost?	—	—	—	—	20%	—	—	—	Varies, but generally about 50%	25%	—	50%	Average of 15%	—	—	25%
9 Remarks as to the success or otherwise of the Tariff	We had 11 consumers on this tariff at end of March, 1913, with total consumption of 30,032 units during year, and so far the 5 tariff has been a success	Fairly successful. Had we warning and hiring powers the scheme would go	—	—	Number of domestic consumers very small for size of town, due to fact that Gasworks owned by Corporation and contributing large sums in relief of rates. 5 tariff responsible for proportionate increase in number of domestic consumers. Not yet left effect on supply system of heating and cooking connections, but have felt benefit on revenue. 5 tariff much appreciated by consumer, entirely satisfactory for heating and cooking, and thoroughly justified its introduction	Only in operation for little over a year.	The advent of the war has restricted the growth of the heating load.	Very successful generally, but high price of apparatus delays progress.	Thoroughly successful	—		It is quite certain that without 5 tariff not 5% of 1,300 kw. of heating and cooking apparatus connected since tariff came into operation would ever have been connected.		I consider it successful in so far as it is one to lend to a more general use for household purposes. Every consumer is highly satisfied, and enquiries were becoming more frequent when the war started.	Results in a much larger turnover at a considerably reduced price per unit, but increased load factor which is obtained justifies the reduced income per unit

TABLE No. 5.

SOUTHAMPTON CORPORATION ELECTRICITY SUPPLY.

Year ended 31st March.	Connections during Year.					Continuous Total Connections in Kw.	Maximum Load on Feeders.
	Lighting.	Power.	Heating.	Cooking.	Total.		
	Kw.	Kw.	Kw.	Kw.	Kw.		Kw.
1910 - -	340	57	16	—	413	2,759	1,670
1911 - -	310	53	185	—	548	3,307	1,899
1912 - -	446	232	605	198	1,481	4,788	2,213
1913 - -	402	251	519	169	1,341	6,129	2,630
1914 - -	372	288	400	47	1,107	7,236	3,161
1915 - -	264	292	293	—	849	8,085	3,091

Year ended 31st March.	Heating Units Sold.	Price per Unit for Heating.	Total Units Sold for Lighting, Power, Heating and Cooking.
1909 - - - -	11,764	1d.	1,451,485
1910 - - - -	13,361	1d.	1,622,559
1911 - - - -	189,038	½d.	2,186,051
1912 - - - -	436,219	½d.	2,764,996
1913 - - - -	836,912	½d.	3,600,621
1914 - - - -	1,040,066	½d.	4,479,127
1915 - - - -	1,290,442	½d.	5,159,671

The reduction in heating and cooking connections during the last two years in Southampton is due to the agitation of a small minority on the local Council against the adoption of cheap units. The public feared an increase in price and our staff had the greatest difficulty in getting any orders.

(*Signed*) H. F. STREET, *Borough Electrical Engineer.*

"POINT FIVE" TARIFF DISCUSSION.

Mr. G. Wilkinson (Past President) (Chief Electrical Engineer, Harrogate), thought the value of the paper consisted mainly in the fact that it was a statement of facts and not merely of opinions. Anyone reading it through however, must come to the conclusion that the authors had not accomplished the object which they had set out to attain. The plea was put forward, and quite rightly, that many gentlemen who could have furnished important information had been prevented doing so by reason of extra duties involved by the war, and he would like to make an appeal to those who had this information to produce it either in the form of remarks or send it to the Secretary so that it could be embodied in the Proceedings. He regretted that a paper had not been submitted to the meeting from one of the "Point Five" towns which lived upon a residence revenue. It could not be said that this was the case in the two towns mentioned in the paper. Mr. Roles, at Bradford, was supplying 1,298 private residences out of a total of 4,494 consumers. The revenue from these residence consumers represented £7,260 only out of a total revenue of £137,000. Again, in Sunderland, there were 489 private residences supplied out of a total of 1,687 consumers. The revenue from these residences only amounted to £3,924, whereas the total revenue was £65,600. Again the figures put forward on pages 14 to 16 further confirmed this contention because Bradford showed that the increase due to the Point Five Tariff was 94·9 per cent. in units sold—a very healthy increase indeed—but in revenue this 94·9 per cent. increase actually involved a drop in revenue from £1,566 to £1,358. It was obvious that in the case of towns depending chiefly upon residence business this would soon land them on the wrong side of the ledger, and perhaps Mr. Roles would give further information on this important point. At Sunderland the increase in sales was as much as 109 per cent., but again it was seen that the revenue had dropped from £672 to £616. If these were the only examples cited in the paper it would be very depressing indeed, but turning to the schedule at the end it would be found that the revenue from other towns had substantially increased with the growing output and that was a favourable sign not seen at Bradford or Sunderland. When he read the paper he looked up some figures he got out in 1911 referring to the Harrogate extensions. The Harrogate undertaking had to live largely upon residence business and he analysed

no less than 918 accounts of private residence which were supplied at 5d. flat rate or at 6d. and 2d. These private houses produced £5,702 ; taking the Point Five Tariff and a 15 per cent. Rateable Value, this revenue would have increased to the substantial sum of £7,572. The full Rateable Value was taken on every instance including houses with large grounds attached, but it was felt that this was not the proper basis of assessment in the latter cases and the sum of £500 could be deducted from the increased revenue for the extra land. Thus under the Rateable Value system of assessment and ·5d. per unit, the undertaking would be receiving £7,000 compared with £5,702 on the old system of charging. This showed it was a really sound proposition if its general adoption could be secured. There was no doubt that when consumers found they would benefit by the Point Five Tariff they would take advantage of it, but the consumer who found he would not benefit would remain on the old tariff, and therefore, for the time being, the undertaking would suffer a reduction in revenue, but this was counterbalanced by the fact that the residences which took the Point Five Tariff immediately began to use much more current and the temporary slump might be largely guarded against if a condition were incorporated in the Point Five Tariff contract that anybody adopting it must put a certain percentage of other current-consuming devices into their premises before they could qualify. The price in the calculation mentioned was taken as ½d. per unit, and the assessment on a 15 per cent. basis. With regard to the increasing use of radiators there was very little doubt that an immense amount of damage had been done to the electric supply business from the heating point of view by putting in radiators which were much too small for the apartment to be heated. The result was that they were used for a few months in the spring and autumn, but they were put away in the colder weather and probably the user eventually went back to a fire. In this way radiators got a bad name. It was satisfactory to know that in the Point Five districts' radiators were being increased in power, but this necessarily entailed some method of regulation. A 3 kw. electric fire put into a room in charge of a servant would prove to be a very extravagant and expensive luxury without some method of automatically controlling it. He did not wish to enlarge upon this point now because he had devoted a good deal of attention to the matter and hoped to read a paper on the subject during the winter when he would deal with the question more in detail. As to water heating, it was absurd to expect that people could afford to pay ½d. per unit for water heating, and furthermore, it was

not necessary that they should. The electric heating of water had been very severely condemned on more than one occasion, but in his opinion it was largely owing to people having employed apparatus which had prematurely failed or was of low efficiency. It was a fact, however, that to-day it was possible to obtain apparatus which would give a 100 per cent. load factor and take ½ kw. only. At this maximum working, the apparatus cannot consume more than 12 units per day, and the supply for this could well be given at ⅓d. This would work out at 4d. per day, and would compare well with other methods. The apparatus would provide a household with 65 gallons of water per day raised from 50° to 100° F., and under normal conditions in a small household he contended that this was ample. If a further supply was required it would be easy to have another 2 or 3 kw. installed which could be supplied through the Point Five meter. This would be a good investment from the central station point of view and also from that of the consumer. In this matter of the electrical equipment of the household there was one factor which he had never heard put into the equation, and that was the saving of domestic labour. It is possible, by adopting these electric labour-saving devices, having no coals to handle, no grates to clean, no cinders to clear out and very little dust, to dispense with one domestic. Thus £40 a year is saved which would go a long way towards paying for the whole electric supply.

Councillor Dymond (Hereford), said the paper left two impressions upon his mind. The first was, that it is a good thing to cultivate a heating and cooking load, the second that the Point Five Tariff was the way to do it. At the same time it was an exceedingly dangerous doctrine to put forward without reservation that it was a good thing to cultivate a heating and cooking load. The truth was that whilst it suited many places it would be disastrous in others. Local circumstances must be taken into account. He had, with the assistance of his engineer, gone very carefully into the question as it affected his district, and there was no doubt whatever that it would prove disastrous there. In any district they necessarily started with the upper-class residential houses. In Hereford these were situated in districts quite separate from each other and at considerable distances from the centre of supply. It was therefore impossible to use ring mains and the difficulties of feeding would be very great. For instance, the cable which supplied his own house ran 2,400 yards from the nearest feeding point. These houses were of rental values between £50 and £150 per annum, and the

larger houses were at the far end. Again, these houses were all late dinner houses and that implied considerable difficulty in taking the load between 7 and 8 because the cooking load would come on top of the existing lighting peak. He had calculated what would be the result if the houses on that cable were to take cooking. There were 41 consumers and it would be necessary to treble the cable, and, in nearly all cases to double the services. These services averaged over 100 ft. in length and it would involve an expenditure of £4,000 for these 41 consumers, and whatever current they took would never do more than at most cover the capital cost, if it did that. From the point of view of the Council, having got the business and spent the money, it would be necessary to show that they could make a profit, not merely an ordinary working profit but a better profit than the Gas Department were at present making, which was, of course, a very different thing to a working profit. The Gas Department at Hereford had an exceedingly healthy heating and cooking load. There were 2,500 cookers in a town of only 22,000 inhabitants, and 600 gas fires, and therefore the Electricity Department would have to do better than make an ordinary working profit before it could justify to the Council any such action. In addition to this, such districts were liable to grave difficulties in maintaining the pressure. The point had not been introduced into the paper, but it was introduced in the paper read on cooking and heating two years ago. It was a fact that cookers required more constant pressure than any other form of apparatus. If he were provided with a frying pan, a rasher of bacon and a stop-watch he would undertake to tell the pressure at the station within 3 per cent. accuracy. That was no fancy picture for it had happened during the past winter that the ruler of his house had told him that the volts at the station were down because she could not cook the breakfast, and by checking them on the recording meter he had found that the pressure was down 7 volts. That this difficulty of regulation existed was seen from Table IV. The question was asked whether there had been difficulty. Most of the places referred to had only one or two years' experience, and it was not very comforting to find that many of them had already experienced the difficulty. West Ham stated that they had had several expensive additions to mains; Worcester was very frank indeed and said that there had been difficulty, they made no bones about it; at Wrexham difficulties had been experienced and at Blackpool they had had to replace a few services. Barnes had had a certain amount of difficulty. It *was* a difficulty, and in certain places such as Hereford he ventured to think that

it would be an intolerable difficulty. Therefore he hoped it would not be laid down as an axiom that heating and cooking in all cases was a thing to be desired. As to the Point Five Tariff he could not see any particular virtue in it except that it was better than a fixed rate. A tariff might have many virtues, but there were three principal ones which it certainly should possess. First, it should produce a profit ; secondly, it ought to deal with absolute fairness as between consumer A and consumer B ; and thirdly, it should be able to be applied if not to all consumers, at least to the largest proportion of them. It did not seem to him that a Point Five Tariff necessarily complied with any one of these points. Turning to Table III., as Mr. Wilkinson had already pointed out, such a tariff might not only reduce the profit, but also the gross revenue which was a very serious matter. At Bradford, where the lighting load was insignificant, it did not so much matter, the nett result apparently was that the consumers who had taken this system up had been presented with 89,000 units and in addition had been given a cash bonus of £197. That was all right when dealing with 28 million units, but it would not do in much smaller places, and he defined a small place as one dealing with less than two million units. If a town of that size adopted such a system with such a result he did not know what would happen to the engineer, but he was quite certain that the Chairman of the Committee would get the "bounce" in November. Then again, at Sunderland, the same thing had happened. Sunderland, however, was not quite so generous, although it presented 48,000 units to its consumers and a cash bonus of £56. At Worcester again, they gave in their generosity 16,500 units and a cash bonus of £1. This might be all right, but it really did not strike him as business. He could understand having the price per unit lowered as much as they pleased, and at Hereford some units were sold at 0·3d. per unit, but he could not stand having his gross revenue reduced, because units could not be generated for nothing. Looking down the list of towns it was seen that the extra revenue derived from the Point Five Tariff was insignificant. Ilford only realised 0·14d. for its additional units, and he did not think that Ilford could generate a unit for that price seeing the coal cost 0·56d. per unit last year. Only one place was apparently realising a profit and that was Marylebone, which obtained 1·6d. per unit, and it was significant that Marylebone was the only one which had not adopted the Rateable Value system, but had the kw. demand system. This brought him to his second point, viz., the necessity for dealing equally with all consumers. If there was one thing

in a small town—he did not know about a big town—it was that they would land themselves in trouble and bring innumerable charges against them of undue preference if they adopted the Rateable Value system for determining the charge. Why a rateable value at all? What had rateable value got to do with the cost of generating electricity? He had looked into this matter and had taken a certain number of Hereford consumers, who, at the present time, paid the same bill for the same quantity of energy. He would for the purpose of his illustration select two. They each paid about £14 a year. On the basis that they were charged 15 per cent. on the rateable value and ½d. per unit, instead of them both paying £14 one would pay £8 and the other £20. In a small town that would undoubtedly cause trouble, and he could see no point in doing it. The only plea raised for rateable value was that they must have something the consumer could understand. He differed. What was wanted was something the consumer *thought* he understood and he would undertake to make any consumer think he understood the maximum demand system within five minutes. It was perfectly easy to do. The consumer thought he knew all about it and was quite satisfied, and furthermore, the system had the benefit of being truly scientific. If the consumer used it he got his units cheap and if he did not he had to pay for them. He found it better in talking to consumers to speak of h.p., and if they were made to understand that they had to pay interest on so many h.p. at the station they understood it quite easily. The Rateable Value system did not lend itself to equality but apparently it did lend itself to producing a tariff which landed the Undertaking into a loss. Lastly the Rateable Value tariff should apply to all consumers if possible. The paper, however, said that it only applied to households and this left their business premises out. Consequently, they must have two tariffs and he was wondering what would happen in the case of a hair-dresser who had a shop. He had heating and a motor in his shop and a cooker in the rooms above where he lived. Consequently he would have three tariffs, a flat rate for shop lighting, presumably, a kw. demand rate for the motor in the shop and a Point Five Tariff for the cooker upstairs. This was a complication and it was much better to have one tariff for all consumers, and for this reason he was in favour of the kw. demand charge and so much per unit. This could be applied to business premises just as well as to private premises and got over the multiplicity of tariffs. They would all welcome any move to do away with the flat rate, because the flat rate killed all business, but those who represented small

places should, he thought, hesitate considerably before adopting the tariff advocated in the paper.

Mr. C. H. Wordingham (Past President), said it was almost incredible to him that there should be people brave enough to make the dry bones of tariffs live at this hour of the day. He felt that it wanted consummate cheek on his part to trot out arguments and observations on the question of charging which he made more than twenty years ago. However, if they desired to discuss tariffs he hoped they would forgive him telling them things which they must be perfectly familiar with. In 1893 the Hopkinson system of charging was introduced in Whitehaven and Manchester, and it fell to his lot to make the consumer, whom he must confess he did not find so readily convinced as the last speaker had stated, understand or think he understood, the fixed charge plus a meter charge system. The argument which he found was effectual was "wait and see" when your bill comes in you will find how much less it is on this mysterious method than on the flat rate." His words were usually justified. He did not find the most difficult people to be convinced to be the consumers. He found the members of the Committee were even more difficult, but he was thankful to say that as long as he had anything to do with the matter he was able to continue that fixed charge method which was, in his opinion, the only method by which they could possibly have a fair charge to every consumer. He agreed fully in the contention that all should be treated alike. Not long after the introduction of the Hopkinson system there arose Wright, Madgen and Reason, and they preached all over the world the doctrine of the demand indicator. Their system was really no other than the Hopkinson system except that the basis of determining the maximum demand was different and they to some extent discredited the Hopkinson system so that for a while the Wright system carried all before it. Now, however, the Wright system did not seem to be in such great favour and people were rediscovering the Hopkinson system. Not many years ago they found men like Handcock and Dykes in that very room rediscovering, with a tremendous flourish of trumpets, as a great novelty, the Hopkinson system. They seemed to think it had something to do with metal filament lamps and now the Point Five Association had rediscovered it and they were bringing it forward and advocating it for all it was worth, but it was still the Hopkinson system, although they had mutilated it worse than anybody else had. He had never yet been able to understand what "Point Five" meant. He

assumed that the "Point" was what commercial people called a "talking" point. The "Five" part of it baffled his mathematical understanding altogether. As far as he could make out from the paper the only "Point Five" gentleman was the Luton one, because when they looked at the figures they found that at Bradford "Point Five" meant 1¾d., and at Sunderland it meant a little over 1½d.; therefore he did not understand what Point Five was at all. It reminded him very much of the earliest Power Companies who used to talk to Parliamentary Committees about the fabulously low charges at which they were going to supply energy, but they quite forgot to say that there was something besides their charge before the consumer was reached. These power companies were supposed to be going to help the consumer to get cheap power, but when the consumer found out that he had got to add the distribution charge it was a very different tale and as a consequence the Power Companies were not the gigantic success some people anticipated, nor had it been found that they had seriously affected the Municipalities who were now generating so extensively. He disagreed entirely with the Rateable Value system of charging. In his opinion it was wrong from the supplier's point of view and this was borne out by the fact that, as appeared from the paper, when once a supply undertaking adopted it they did not stick to it but immediately began to hedge it round with all sorts of exceptions and varied the charge according to the quarter of the year and so on. He would like to ask one question which seemed to him very pertinent. He had met with this difficulty in the antediluvian days which he had already referred to. Supposing they had a customer charged on the Rateable Value system who had a very bad load factor it might very possibly be found that the average charge on the Rateable Value system worked out at 2s. 6d. per unit. He was afraid that it was not legal to charge at that rate because it was in excess of the maximum figure laid down in their electric lighting orders. When he was concerned with this matter he had to adopt the policy of saying that in those cases in which the charge on the Hopkinson system worked out to more than the standard flat rate (the maximum laid down by the order was 8d., and at the time the flat rate charged was 6d.) then they would only charge the maximum (*i.e.*, the flat rate) to that consumer and not the amount it actually worked out to on the Hopkinson system. He was afraid they would find that if the matter were contested they would have to do that under the Rateable Value system. Then there was the complication of how much land was attached

to the house, and all these things left a very big loophole for discontent. The figures given in the paper clearly showed that a system could not be right which nearly doubled the consumption and yet reduced the revenue. Then it was stated that in houses charged on the Rateable Value basis there was always a blaze of light; the consumer put in bigger lamps; What did that mean? It meant presumably that the fixed charge determined by the rateable value had been based upon a consumption and use of lamps at the time the flat charge arrangements were made. If after that, the consumer doubled or trebled the maximum demand for the lighing, it would appear that the charge made on the original assessment must have been much too high if the rates were profitable on the larger lamps or else the undertaking was getting a worse load factor than had been anticipated. The load factor from the consumers on this tariff of 5 or 6 per cent. claimed in the paper was surely nothing to brag about. They should get a very much better load factor than that to justify such low prices as those cited. He contended that it was essential to have fixed charges which bore a proper proportion to what the fixed charges cost, and a running charge which had a proper proportion to what the running charges cost. Thus the fixed charges per kw. plus a charge per unit was the only sound system of charge and it should be adopted in all towns of the kingdom. There was one word he would like to say, although it was extraneous to the principal matter of the paper. He did not believe for one moment that it was possible to heat water electrically as Mr. Wilkinson had suggested, economically, in sufficient quantities for ordinary domestic supply, and he firmly believed that the cause of electric supply was damaged by statements to the contrary. With regard to radiators, they had been told that it was an advantage that their capacity was being greatly increased so that they were heating the air instead of the individual. From the point of view of wholesome heating he believed this was entirely wrong. On hygienic grounds it was essential to keep the air cool and to warm the individual himself.

Mr. W. W. Lackie, Past President, (Chief Electrical Engineer Glasgow), said that this was a very interesting and instructive report by the two members of the Point Five Association. The report, however, bore out what was shown by the paper read at last year's Convention by Mr. Bowden, viz., that energy was not supplied at 0·5d., but rather at something like 1·5d. per unit. If the example given of a house of £40 rateable value was a fair average, it would be seen that with a consumption of 1,000

units the average price was 1·56d. and for 1,500 units 1·21d. There was also some discrepancy in the figures given in the statement further on that the average units used by the houses under the old tariff were 680, whereas the table given at the foot of the page showed 367. The same was true of the figures given with the Point Five Tariff. In both Sunderland and Bradford he noticed that the effect of the introduction of the Point Five Tariff had been to reduce the revenue per house below what it was when the tariff was 4d. per unit. They had a tariff in Glasgow which had been fully described, but before fixing that tariff his main endeavour had been to see that the revenue per house was increased and not diminished and their tariff practically amounted to this : If a consumer was paying £5 per annum for lighting his house, he got excess units over this at ¾d. without the necessity of having an additional meter and separate wiring. Their charge for a £40 house was 3d. per unit for the first 200 units per annum and ¾d. thereafter. The 200 units were allocated *pro rata* to the hours of darkness over six two-monthly periods. Such a domestic consumer's bill with heating and cooking would probably be :

	£	s.	d.
200 units at 3d.	2	10	0
400 units at ¾d.	1	5	0
	3	15	0

or an average price of 1·51d. which was the same as what was offered by the Point Five Association. In his own house the charge was 300 units at 3d. and all further units at ¾d. The total annual consumption was about 1,500 units or 1,200 units for heating and cooking. This gave a total bill of £7 10s. and an average price of 1·2 per unit. There were in Glasgow 10,000 domestic consumers and 2,300 of these had taken advantage of the system described and these consumers had taken 600,000 units for heating and cooking purposes. The 2,300 consumers who had installed heating and cooking apparatus had increased their domestic consumption from 500,000 to 1,100,000 units. The principal matter of interest from a domestic point of view in Glasgow, however, was that fully a year ago an enterprising builder started the erection of a number of houses and equipped them electrically throughout. There was one ventilator to each room in place of a chimney. Heating cooking and lighting were all done entirely electrically. No other sort of fuel was allowed inside any of these houses. One of the houses had been occupied for a year by the builder himself. The units used

were 16,000 and the total bill £51 8s. The average price per unit worked out at 0·77d. This was for a house of five apartments and the occupier expressed himself as being quite satisfied. Another two houses had now been occupied for three or four months and an additional three houses were ready for occupation. The installation in these houses consisted of fifteen metal filament lamps and radiators, cooker and hot-water heater to the total capacity of 12 kw., the five radiators taking 6 kw. and the cooker and water heater taking 3 kw. each. The occupant of the first house had been fairly lavish in his use of electricity as he (Mr. Lackie) found that the other two houses were not likely to exceed 10,000 units per annum. Some years ago he had looked into the question of power factors, load factors and diversity factors, and in a town near Glasgow, which is entirely residential, he had found that the ratio of maximum demand on the station to lamps installed in the houses was as 1 is to 5. A large block of tenements in the West End of Glasgow was taken, and there it was found that the ratio of maximum demand on the feeders supplying the block to the lamps installed was as 1 is to 6. This he did not think confirmed the diversity factors of 2·6 and 2·9 given in the paper. He confessed that he was not perfectly certain of the conditions with which one must comply to entitle him to be a member of the Point Five Association, but he noticed that the West Ham engineer was a member and his tariff was £10 per kw. per annum plus 0·5d. In Glasgow they had been selling energy for some years at £10 per kw. plus 0·15d., which might possibly disqualify him from being a member of the Association. At the same time and joking aside, the Point Five Association deserved their hearty thanks for the energetic manner in which they had sought to educate the public as to the use of electricity for purposes other than lighting.

Mr. J. H. Bowden (Borough Electrical Engineer, Poplar), said he had special pleasure in congratulating the authors, as they had both been at Poplar in the early days. He further congratulated them upon their legal abilities in endeavouring to make what was really a bad case into a good case. He desired to be perfectly fair with regard to the Point Five system. He was a great advocate of it and thought it was absolutely right. The only thing that he joined issue with the authors upon was the question of assessment and how that was arrived at. The system which he had adopted at Poplar, and which was described in his paper last year, had been under consideration by his Committee for two years before its adoption, and therefore was

probably earlier than the Norwich Rateable Value system. This long consideration could be easily understood when it was remembered that its adoption either meant total failure or success to the undertaking. It had been hinted to him that as his figures for Poplar were not included in the paper this year, he had been afraid to publish them because they were so detrimental but he would show a little later that they were not so. He would like to know whether it was really a fact that Southampton was now charging on the Point Five system on the condition that the consumer had a number of lights at the ordinary lighting rates. He was under the impression that after the report from Sir John Snell, Southampton had decided to somewhat modify its tariff and he would like to know if this were so. One of the points which showed the weakness of the Point Five system was where the authors said that it would be more strictly correct in individual cases to charge on the fixed price basis. This seemed to him to be the whole point of putting expediency before equality, an expression for which they were indebted to Mr. Seabrook and which had been very convenient in many ways. It seemed to him that it was no more difficult to arrive at a true fixed charge taking the amount of radiators, heaters, lamps, etc., installed than leaving the whole thing to another department, who knew nothing at all about the assessment on an electrical basis. That to his mind was one of the most serious points in the whole thing, because those who had experience of other Municipal departments, which more or less had something to do with the accounts, knew that in some cases these departments regarded themselves as electrical experts, and it was a very weak point in the Rateable Value system that they had to ask another department to assess the man they were going to charge. That contention was borne out again by the variation of 10 per cent. to 15 per cent. according to the value of the house. Did the authors have intermediate percentages which they varied according to the size of the house? If so, surely it was going back to the principle of having a fixed charge, for they simply made the percentage to suit the particular conditions of the house. The authors stated they fully recognised that the Rateable Value system had its disadvantages as well as its advantages, but the only advantage that the rateable value could claim in his opinion over the proper fixed basis, was that of simplicity. At Poplar in 1910 the first complete year after his own system was adopted, the output was nine million units, the average price received was 1·2d. per unit, the total costs 0·65d. and the net profit £3,700. In 1914 the output had increased to

sixteen million units, the total costs were 0·55d., the average price received was 0·97d., and the profit £8,010. For the past year to March 31st, 1915, the output had practically remained the same, being nearly seventeen million units, the total costs were 0·51d., the average price received 1·04d. and the profit had increased from £8,010 to £14,749. That was a clear indication that at any rate the system of charging in Poplar was on a sound basis and in addition to that, he thought he could claim it to be the only Undertaking in the country that had been able to reduce prices since the war broke out. For domestic supply they had reduced the prices practically 25 per cent. With regard to hiring out radiators, cookers, etc., he was perfectly satisfied that very little progress would be made in this direction unless the apparatus was let out on hire. During the last two years, Poplar had put by a certain amount out of profits and was now prepared to let out small apparatus, such as fans, irons and radiators free of charge in order to create that load and to try to get the consumers to realise that something could be done. This, he believed, would bring in quite a big revenue and the amount which had been set aside out of revenue in the past would be more than compensated for in the return that would be obtained. The difficulty with regard to the amount of ground attaching to a house again showed the enormous disadvantage, if not the inherent weakness, of the Rateable Value system. Here again they had to go to the Rating Committee to ask them how much they allowed for the garden. The claim made for simplicity in the Rateable Value system could also be made for the system as adopted in Poplar. There were certain other advantages which he also claimed for his tariff, and perhaps the most important one related to the question of high efficiency lamps. Before long we should have half-watt lamps of reasonable candle-powers and on a flat-rate there must be an enormously decreased revenue unless something in the nature of a fixed charge plus a small charge per unit was adopted. With half-watt lamps and a 4d. flat rate the revenue would be reduced by half, and this would be a serious item, but with a Point Five Tariff it would only be a question of reduction from 0·5d. to 0·25d. He did not agree with the authors that it would not be necessary to increase the charges on account of services, because when cookers were put in it invariably necessitated larger services, especially if the apparatus were 5 to 7 kw. That was another point which made him emphasise the fact that a system could not be right which did not make some charge or get some revenue for that extra expenditure. The same thing applied to manage-

ment. Up to a point he was inclined to agree that the management would not be increased, but if the thing extended to any large degree there must be increased management charges after a certain period. In conclusion he wished to emphasise the principle that as far as the Point Five system was concerned as a system, *i.e.*, a fixed charge plus a running charge of not more than 0·5d. per unit, it was correct. It was absolutely the right and sound principle and he hoped that engineers would give it very serious consideration, but in giving consideration to the Point Five system, very grave thought should be given to the fixed charge as against the rateable value.

Bailie Stevenson (Edinburgh) said his purpose in intervening was to put one or two points of difficulty from a Convener's stand-point. He had no doubt that the object which the advocates of a Point Five Tariff had in view was to popularise the use of electricity for domestic purposes, but while he was prepared to consider any new system of charges which might be brought forward to accomplish this, yet he did not think that the facts and figures in the paper were convincing. One point of criticism which appealed to him was that a Point Five Tariff based on the Rateable Value system would, for example, be much larger in Edinburgh than a Point Five Tariff in Glasgow, for the simple reason that rents in Edinburgh were from 15 to 20 per cent. dearer than in Glasgow for the same class of house. There were, too, he thought, some rather unfortunate remarks in the paper, one or two of which would give the Editor of the *Journal of Gas Lighting* food for jollification at all events. For instance, it was stated that those who had adopted the Point Five Rate now used high-power lamps, and as a result their houses were now lighted at least equal to those by gaslight. That was not his experience. In Edinburgh every year hundreds of ratepayers took out their antiquated gas fittings and put in electric light, and they were always satisfied at the end of the year that they had a cheaper and a much better illuminant. With regard to the effect on the undertakings, the authors stated :

> " As a result of our experience, the writers are firmly of opinion that any reduction in profits from quite a limited number of consumers is soon far more counterbalanced by the profits derived from the additional consumers gained by reason of the excellent advertisement obtained in consequence of the improved lighting."

He would like further information on that point. In the first place did it really bring in many new consumers, and in the

second place did the increased consumption justify the additional cost of plant? With regard to Sunderland it was stated that since January 1st, 1912, the three years' working had resulted in 162 more private houses being connected and of these only 100 had adopted the new rate. That, in his opinion, if not an absolute failure was a comparative one. Certainly a system would never appeal to him that could only bring in such a small number of new consumers. Again, they were told that under the old tariff there were 44,827 units used by these consumers, whereas now their consumption for the same period was 95,327 units, and yet the revenue was less for the larger number. When they came to the average number of units used per house then they found that it had increased from 512 to 1,073. But if this did not mean that their consumption was now spread over a larger number of hours than formerly, but was brought about by using a greater number of lamps during the usual time, then it meant that at the station new plant had to be put in to cope with this additional load at the peak—in other words, increased capital expenditure without any corresponding increase in revenue. These were the points of difficulty which appealed to him, and he was bound to say that up to the present the advocates of this system had not said anything to induce him to adopt it as far as Edinburgh was concerned.

Alderman J. P. Smith (Barrow-in-Furness) thought that certain remarks made by the representative from Hereford should not be allowed to go unchallenged. That gentleman had said that he and his engineer had come to the conclusion that a cooking and heating load would not be a paying proposition and the reason for coming to that conclusion was that they were convinced that the large houses which it was anticipated would adopt heating and cooking first, were on the outskirts of the town and therefore a long way from the generating station, and that it would result in a very large increased cost in the way of mains. Further, that as the occupants of these houses would be late diners they would get all the additional load on the existing peak. He thought this raised a bogey which did not exist, and if they inquired of engineers in towns where cooking had been adopted they would find that it was not the big houses that came on first but the middle-sized houses, say from £40 rental down to £25 or even £20 and the question of increased cost of mains did not apply with the same force as with larger houses. The bulk of the people in these houses had their dinners at mid-day and they did not

all have hot dinners on the same day. They all probably had their hot dinner on Sunday, but the load then was very light and the load factor was very good, and there was a good diversity factor. Therefore, if the Hereford representative made further inquiries he would find that the results would be very different from those anticipated. Another reason why larger houses were not so likely to take up electric cooking before the middle-class house was that the owner of a large house, say of £100 or £150 a year rental value, did not personally derive the same advantage from the adoption of electric cooking. He certainly got his cooking better done, but it was in the smaller houses where the wife did most of the cooking herself, that the many incidental advantages of electric cooking were really felt and appreciated, and when personal control would ensure economy in working. The domestic servant problem was becoming very acute and would do more than anything else to promote the adoption of electric cooking and heating.

Mr. R. A. Chattock, Past President (Chief Electrical Engineer, Birmingham) said it struck him that the speakers had been more destructive than constructive in their criticism, and he could not help feeling that they were all tinged with the fact that they were too local in their outlook. They were trying to prove that this form of tariff was applicable to one town and not to another. No doubt they were right as far as their own limitations were concerned, but it was necessary to devise tariffs to attract more business. Some speakers had said that in an industrial town they could afford to put forward tariffs and lose something on certain consumers, that these tariffs attracted more business and that in the end things came out all right. A purely residential town with a small output could not afford to do that, and they were quite right not to. Industrial towns began their supply with a lighting load and put forward low tariffs to attract power supply. They were criticised on the ground that they were going to lose money and some of them did, but the low power rates soon justified themselves, and these towns were doing very well now. In fact, in some of these industrial towns the power supply was far greater than the lighting supply which was now becoming a by-product and they could now afford to charge low rates for lighting and to offer a special tariff to attract a heating and cooking load in the same way in which they built up their power business. That was all very well in industrial towns but it could not be done in residential towns where they had not the backbone of a large

power supply, and they must feel their way very gingerly or else they might be faced with a loss for some years. This brought him to the point that all these developments going on were justified if they could only be combined together, and led him to the conviction that all the different supplies of electricity should be combined into one large centralised scheme. In that way only full advantage could be taken of the diversity factor over the whole of the country and consumers be supplied on the most reasonable terms possible. He felt that it was only by this centralisation of the supplies of the country that we should ever reach the Utopia which was aimed at of electricity for everything whether lighting, heating, cooking, power or any other purposes and at one rock-bottom price.

The Chairman said that most of the speakers had been rather critical on the Point Five Tariff and it might be well to have one or two speakers from the other side now.

Mr. W. H. Cooke (Chief Electrical Engineer, Luton) thought the authors of the paper had done very well up to a point because they had tried to make a good case out of a very bad system. He did not believe in the Rateable Value system ; it was not equitable. The rateable value of a house had nothing whatever to do with the consumption of electricity in that house. In Luton there was a simple flat rate of ½d. per unit for heating and cooking purposes, and a good many people might say that it was impossible to supply at that rate without an additional fixed charge. In arriving at that ½d. per unit he had to consider first whether heating and cooking would stand a higher charge and his conclusion was that it would not. It was impossible to supply heating and cooking at a higher price than 0·5d. per unit, and that must include capital charges. Moreover, he had found that 0·5d. would very well include capital charges. The only sound basis of fixing a tariff was the Hopkinson system in which the whole of the capital, standing and running charges were taken into consideration, otherwise they must come to grief. Having taken that system as a basis it was possible to fix their charges either by a fixed price per kw. and a running charge, or these fixed charges could be split up over the units and a higher price charged for the unit. One great objection he had to the Rateable Value system was that it could not be supplied to business premises, yet the heating load of business premises was equally as valuable as the heating and cooking load in domestic premises. In the returns given in the paper,

the largest number of units given for domestic purposes was 185,000 at Bradford. In Luton which was a very much smaller town in population than Bradford, they had sold about that same number for domestic purposes, and in addition nearly half a million units for business premises. This did not refer to industrial heating, but power for heating business premises and offices, and this load was obtained because it was supplied at ½d. per unit. It might be said that they were losing money on that, but last year there was a considerable increase in the output and 35 per cent. of that increase was due to the units which were sold at, and under ½d. per unit, and the financial results were that the gross profits had gone up in exactly the same proportion as the gross revenue, but the gross expenditure had not gone up in the same proportion. They had made very much larger net profits in proportion than were made in previous years. If he had been selling at a loss that could not have possibly taken place, and there must have been a reduction in the gross profits. The two main points to be considered in connection with the Point Five Tariff was whether it would bring in more consumers and more profitable consumers, and he was absolutely certain in his own mind that it would do so, but if they charged higher prices they would not be able to attract such consumers. There was a figure in any industry at which the business was driven off the market altogether. One great drawback which he had experienced but which was not referred to in the paper was that the hindrance at the present time was not because tariffs were not suitable but because of the high price of the apparatus. Those towns which had a hire system in operation would undoubtedly make more progress than those towns which had not. It was absolutely essential to have a hire system in operation for heating and cooking purposes, because the high price of the apparatus was appalling and absolutely prohibitive for any consumer to buy except for large houses; and large houses were such a small percentage of the total number of houses that they must be considered very small in comparison with the medium-sized houses. It was the medium-sized houses from which they were going to get their revenue.

Councillor Crowther (Member of Council) (Sheffield), said he was a strong supporter of the Rateable Value system, for what he believed to be very good reasons from a layman's point of view. One of its chief advantages was its simplicity, because if a man was told that he was going to be charged upon his

Rateable Value he knew immediately what his electricity was going to cost him so far as the minimum payment was concerned. There had been some criticism that the system did not commend itself for business premises, and probably that was so, but it would eventually be made applicable to business premises. The drawback at present was that business premises in the centre of large cities were so heavily rated that the occupiers naturally hesitated to come upon the Rateable Value system unless there were other considerations. The advocates of the Point Five system were most anxious to bring in cooking and heating, and so far the Association had been very successful from that point of view. The value of this load, of course, was that it was practically a day load. He himself had been using both systems of charging. For something like seven years he was on a flat rate of 4d. for all purposes but at the first opportunity he went over to the Rateable Value system. Immediately his all-round cost went down from 4d. to something like 1¾d., and taking the average of a number of houses in large towns with a Rateable Value of £25, the cost worked out to about 1¼d. per unit. For houses of £30 Rateable Value it went up to 1½d. and at £40 it went to 1¾d. so that the larger the house the higher the cost. This he agreed was why some people thought it unfair to charge on the Rateable Value system, viz. that one ratepayer consuming the same rate of energy as another, paid more for it. This, however, was an absolutely fair principle and it had been recognised for several years in connection with water supply. There were now many people paying more for their water and yet only used about half the quantity of others who paid the same amount of money. The question of gardens was important and must be taken into account. He was in a house a fortnight ago which was rated at £250 because it had something like 16 acres of land attached to it whilst the house itself would not let at more than £60 or £70 per year. Therefore some allowance should be made in those cases where large grounds were attached to the houses. In Sheffield the adoption of the Point Five system had been a good thing, although they had been told that the system was like the curate's egg, it was good only in parts, and that whilst it might be good for industrial districts it was not suitable for residential districts. In his opinion taking the thing all round it was good for everybody. There was the alternative that some day they would have the courage to reduce the ordinary flat rates by one half, and probably if there were a universal flat rate of 2d. per unit instead of an average of 4d. that would bring in a larger number of

people than the Rateable Value system did. Such a reduction might in the first place, involve considerable loss of revenue, but if Municipalities had the courage to do it, it would work out all right in the end. The effect would no doubt be similar to that which happened at the time when metal filament lamps were introduced. In Sheffield they were so alarmed at the drop in revenue that they thought of trying to conceal the fact from the public that the new lamps made such a big reduction in the cost of current. They wanted to get rid of a very large stock of carbon filament lamps before they let the consumer know the things that were waiting for him. That, however, would have been a bad policy and therefore they made the public fully aware of the advantages of these newer lamps. There might, at first, be a temporary set back as far as revenue was concerned but they must face these losses as business people. He agreed with Mr. Chattock that some day it might be that electric supply would have to be nationalised and that local committees instead of carrying on their own particular undertakings in a separate area and competing against each other, would have to take into consideration the question of national supply rather than local supply, and to look after the requirements in their own districts, taking their supply from the national source. When the industrial history of this country was written he believed it would be found that the electrical industry had rendered magnificent services during the crisis of this war, and perhaps when the war was over and all the lessons which it taught came into force, one of these lessons would be the nationalisation of our electric supply.

The Chairman reminded the speakers that the discussion was on tariffs and not on bulk supply.

Mr. A. Nichols Moore (Chief Electrical Engineer, Newport, Mon.) said that, two years ago, he had the audacity to attack the Authors' Tariff, or rather the policy of a certain section of the Point Five Association, in the public Press. He judged that the general trend of the discussion had confirmed his views.

He thought the authors in their enthusiasm had dealt with the subject in too ambitious a manner, and attributed to the Point Five Tariff many things, which the results as published certainly did not justify. Further, their statement that after careful consideration, they came to the conclusion that no substantial progress could be made in the supply of electricity for domestic purposes at any rate exceeding ½d. per unit, is

by no means substantiated by facts. Enquiries, which had been made amongst a number of engineers, showed such not to be the case, and moreover, several of his colleagues in the course of conversation strongly repudiated the suggestion. For instance, Cardiff last year with a 1d. flat rate for heating and cooking had increased their output from 148,000 units to 260,000, and their revenue on this account from £615 to £1,083.

In Newport heating and cooking units had increased from 77,000 to 170,000, and the revenue from £293 to £692. The total number of heaters on circuit had jumped from a matter of dozens to 300, and of cookers they had now made a modest start with 26. In Brighton, Derby and many other centres he found the same results. So much for the question that it was impossible to do anything except with ½d. tariff. At the same time, he did not dispute that a low running charge was an essential inducement to a really extended use, for domestic purposes.

It must come as a surprise to many present that practically all the Point Five engineers with one or two exceptions, were working on the Rateable Value system. Mr. Long was the originator of that system, but still to-day he had not joined the Association. Whether that was a compliment to Mr. Long or to themselves he did not know.

In regard to the Rateable Value system, one of the most experienced members of the Point Five Association had openly stated that in his opinion the Rateable Value system was the most pernicious system ever introduced into electricity tariffs. Evidently there was a wide diversity of opinion amongst the members. For instance, taking table No. 1, out of the whole list given five of them did not know how they arrived at their basis of fixed charge at all, at least they did not give any answer, whilst with regard to the modifications necessary, thirteen had not given consideration to the question. If that was the sort of system they were working upon, the ultimate result did not look very hopeful. Further, it was interesting to note on pages 8 and 9 the difficulties they were already experiencing, particularly in those cases where a considerable amount of land was attached to the houses. Apparently, one of the undertakings was going to make an allowance for this on the basis of so much per acre ; it was to be regretted they had not indicated what allowance should be made per cow ; if they had, probably the right basis would be arrived at.

There was no particular virtue in the claim made by the authors that the system had the great advantage that it did

not matter what errors were made in the estimates or in the meter readings, so far as the net result was concerned, the obvious reason being that in the ordinary residential house the proportion that the fixed charge bears to the running charge is overwhelmingly great.

Another claim made for the Rateable system is that every consumer is on one basis only for all requirements, and thus the necessity of separate circuits and meters was avoided; that really was a great point in favour of the system, and the authors were entitled to take full credit for it, but when they said they could tell by the amount of lighting, whether a house was on the Rateable Value system or not, well, that was asking engineers to swallow a lot.

With regard to the paragraph in the paper that although the Rateable Value system with a low running charge may cause a reduction in profits from a number of consumers who have changed over from old and well-established tariffs to the new tariff, such reduction in the profits is soon far more than counterbalanced by the additional profits derived from the greatly increased number of consumers. This point is emphasised more particularly by reference to Table IV. where Mr. Hame says, "the Point Five Tariff results in a much larger turnover at a considerably reduced price per unit, but the increased load factor which is obtained justifies the reduced income per unit." Such statements were open to strong criticism, and this is possibly one of the most important points in the whole of the paper.

It would be advantageous for all concerned to concentrate a little more of their attention on this aspect of the question. The problem is essentially a commercial one, but one the financial basis of which can only be established on fully recognised, and well understood highly technical principles.

A lot had been said about units sold and revenue obtained; there had been very little reference, however, to the expenditure side of the balance sheet. No one could sell units until they had generated them. Surely we all desired to treat our concerns as essentially business undertakings; it was very necessary that they should do so, especially as they were competing in the majority of cases, with highly-developed private commercial enterprises, and moreover, had to bear the severe criticism not only of those competitors, but a certain section of Municipal officials, particularly Borough Treasurers.

He would like to suggest one way in which the results of the tariff could be judged, a way he thought which would meet the approval of those who are interested only in the financial

results of Municipal undertakings and know nothing of the technical principles involved. It might be put thus: That if the average price obtained for any commodity is a rapidly decreasing quantity, and the percentage of the working costs to the total receipts were shown to be a steadily increasing quantity with these factors pertaining (it is assumed, of course, that capital expenditure will show in any healthy undertaking, a steady increase) the percentage ratio of gross profit to total revenue is also found to be a rapidly decreasing quantity—then he suggested that as a trading concern, the financial position is not so satisfactory to-day as at the commencement of the period under review, and one is entitled to suggest, if not assume, that this condition of things has been brought about by an unwarranted reduction in the price per unit to a certain class of consumer whose load factor does not justify such a reduction in the price as has been given. That was why, in his opinion, it was so much more a debatable proposition to adopt this cheap tariff for domestic supply than to adopt it for the purely power consumer.

He had been led to this point by certain particulars given in the paper, and in the tables attached as an appendix. Taking the figures given on page 14, here we find that there has been an increase of 94 per cent. in the units sold for domestic purposes, whilst there has been a decrease in the revenue obtained of £208. If we assume as a reasonable figure 0·25d. per unit as the cost of supplying the additional units, there has been added to the expenditure side of the balance sheet a further £100 on this account making the total adverse balance as compared with the old tariff of £308. Now, it is quite obvious from the particulars given, that the load factor of this class of consumer is hardly of the order we have been led to suggest on many occasions by those who have at one time or another been defending the Point Five Tariff. It is also obvious that the diversity factor is not of the order which has been suggested so frequently.

Pursuing this point further, he had taken out the results in the case of a number of towns which had adopted the Point Five Tariff, and compared them with similar undertakings that had not adopted it. Taking the cases of Luton, Southampton, York, Carlisle and Marylebone, the average decrease in price obtained since the adoption of the Point Five Tariff was 29 per cent., or if Marylebone be excluded 39 per cent. The percentage of works cost to revenue received, had risen by approximately 15·5 per cent, whilst the percentage of gross profit to total revenue had dropped by 10·5 per cent. It should be remembered that

the gross profit was only of the order of 52 per cent. originally. Against this, he put the cases of Norwich, Nottingham, Leicester, Brighton and Mansfield, the average decrease in price during the same period was only 8·5 per cent., the percentage of works cost to revenue had increased by 5·5 per cent., but the percentage of gross profit to total revenue had only decreased by 3 per cent. as against 10·5 per cent. It had been said that industrial towns could work such a tariff, but that residential towns could not. He entirely agreed with this, and if the same figures were taken out for such towns as Poplar, Bradford and Sunderland, the results as ascertained, would support that view.

He had already pointed out that from the particulars given in the paper, the load factor and diversity factor of the domestic consumer, whilst good, were hardly of the order so often given by those who have at one time or another spoken in defence of the Point Five Tariff. Yet he was quite prepared to admit that industrial towns or towns having a larger proportion of power demand, could, and should, take advantage of the opportunity some such tariff provided to increase the consumption of the purely lighting consumer—the most unremunerative class—but purely residential towns, especially the small undertakings who depended almost entirely on their residential load for revenue, could not afford to adopt such a tariff.

Mr. F. M. Long (Junior Vice-President) (Chief Electrical Engineer, Norwich), expressed his disappointment at the turn the discussion had taken. It had got away from the subject. It was not a question of tariffs in general, but the result of the Point Five Tariff, this being a tariff which had a running charge of 0·5d. per unit. It had nothing to do with the Rateable Value or other system of primary charge, and he would not say anything about the Rateable Value system because the whole thing had been so thoroughly discussed already. What he had hoped to hear was the conditions under which a Point Five charge could be made, and what the effect of having a Point Five charge would be on the financial side. There had been a good deal of information as to the increase in consumption, although in many cases the financial result looked really like a loss. He had put against one of the tables what the coal costs were for 1913–14, and found that in the various towns that had adopted a Point Five Tariff there were enormous differences. These varied from 0·56d. at Ilford, to 0·17d. at Sheffield. With the latter figure it was easy to see that current could be supplied at ½d. per unit, but when the coal was costing 0·56d. it was quite

a different matter, and there should be some explanation as to how a Point Five Tariff was justified in such cases as that. In the case of Blackpool, the coal costs were 0·51d., Barnes 0·45d., and Southampton 0·46d. He would like to have more information as to how a Point Five Tariff was justified under these conditions, and if the authors could in their reply, give some explanation it would be really useful.

Councillor Jones (Kilmarnock), said he was not aware of the existence of a Point Five Association before he read this paper, but as the result of reading it he had come to the conclusion that all the advocates of a Point Five Tariff were charging anything between $1\frac{1}{4}$d. and $1\frac{3}{4}$d. The whole thing seemed to revolve round the question of rating. In Kilmarnock they had been working on the Rateable Value system, but their experience had not justified their original firm belief in it. For example, there were two houses in Kilmarnock side by side, of exactly the same size and number of rooms, and using the same number of units, but one was rated at £25 and the other at £32. The result was that one of the tenants was paying some 30 per cent. less for his current than did the other, the difference in the rateable values being solely due to the fact that a passage ran alongside one of the houses, and it was claimed that this depreciated its value. That was one of the little difficulties in dealing with rateable values in connection with electric supply. Another case in Kilmarnock was in connection with supply in Troon, some nine miles distant. The rates in the two districts were not the same. For instance, a large house in Troon, standing in its own grounds, had a rateable value of £80, whereas in Kilmarnock it would be rated at £100 or £120. The Corporation of Kilmarnock was supplying in Troon, and charging this consumer on the Rateable Value system was distinctly unfair. These difficulties were very perplexing, and he would like to know how the enthusiasts for the Rateable Value system could reconcile the anomalies which exsited.

Mr. F. W. Purse (City Electrical Engineer, Carlisle) (*Communicated*), says it is disappointing to note from the abstract of discussion published in the Press, that those who have adopted the Norwich or Rateable Value system, whether with a 0·5d. secondary tariff or not, did not seriously defend it. On the other hand, the opponents of this tariff failed to offer a satisfactory substitute.

It was stated that in 1893 the Hopkinson system was introduced, but for general adoption, and the domestic consumer in particular, it has been easily outrivalled by the Rateable Value system ; likewise the Maximum Demand Tariff has, in a great number of cases, had to be supplemented by a Flat Rate charge.

No one could challenge the fact that the ideal tariff is one based on the kilowatt demand plus a small charge per unit, provided the demand together with its time of occurrence are accurately registered on a suitable meter. Such a course is not commercially possible on a large scale, as the cost of the instruments would not be justified for small consumers. The alternative put forward and adopted is to *assess* the kilowatts installed, and *assume* a diversity factor.

The supporters of this system do not state how often they check a consumer's installation to ascertain whether he has increased the candle-power of his lamps or number of radiators installed, they do not state whether a man with four plugs and one radiator is charged the same as a man with four plugs and four radiators, although one only may be used at once ; neither do they state if the habits of different consumers are considered as this must affect their diversity factor.

The whole basis is assumption and assessment left entirely to the Electricity Department—its only advantage seems to be that in the hands of an astute canvasser he will be able to assess and assume to such an extent as to show a prospective consumer that his electricity will work out at a cost he desires it to be, and not what it should be.

It is on this point that the Rateable Value system scores—the Electricity Department do not fix the assessment—it is done by an independent party, and therefore the Electricity Department cannot be open to criticism that they have manipulated the assessment to secure a consumer.

The opponents of the Rateable Value system object to it because it does not fairly take account of the demand, and yet they themselves, assess and assume, and consider it perfectly just and reasonable. It is not claimed that the Rateable Value system is perfect, but it is equally as good as any other system that relies upon calculations, and not registrations, for its accuracy.

The writer would also refer to his comments on a paper before the Institution (*Proc. I.E.E.*, No. 245, Vol. 53) regarding the Rateable Value system as a commercial proposition generally. The critics of the Rateable Value system apparently go on the theory that because they have calculated it out and find they

cannot apply it in their own case, they fail to see how it can apply in other cases, but those who have adopted it can say from experience that its adoption has been successful.

One word as to the secondary charge of ·5d. per unit. The Members of the Point Five Association do not suggest for one moment that this should be universal ; obviously it must depend on the cost of the principal factor—coal. If in any district the price of coal is high, naturally the cost of producing electricity must be high, but equally the cost of producing gas must be high, and therefore a higher secondary charge than ·5d. will be found quite a competitive price. Mr. Roles clearly emphasised this point that the basis has been found to be ½d. per unit where gas was less than 2s. 6d. per 1,000 cubic feet.

If the critics of the Rateable Value and Point Five Tariffs would demonstrate what progress they had made under alternative tariffs, and how such progress is in advance of what they would have obtained under the tariffs they criticise, it would be much more helpful than any amount of theory and pious opinion.

The foregoing remarks apply more particularly to the domestic consumer, the one outstanding class which it has been difficult to secure.

Mr. T. Roles (Chief Electrical Engineer, Bradford), briefly replied, and the remarks made by him have been incorporated in the following detailed reply which he has since communicated :

Like Mr. Long, he was disappointed in the turn taken by the discussion. The majority of the speakers seemed to be under the impression that the Rateable Value Tariff and the Point Five Tariff are synonymous, whereas, as a matter of fact, a number of Point Five Tariffs are in no way based on the rateable value system of charging. As has been pointed out by the authors, it is somewhat unfortunate that " The Point Fives " Association asked two persons, both of whom have adopted the Rateable Value System in connection with their Point Five Tariffs, to undertake the preparation of the Report. This being chiefly a statement of the results of the working of the Point Five Tariff in Bradford and Sunderland, it follows that the rateable value system must to a certain extent be dealt with, and an endeavour has been made to distinguish between the results obtained by the adoption of the rateable value system *per se* and the adoption of the Point Five Tariff, as some of the results, whether favourable or otherwise, would no doubt have been obtained had the two undertakings been working under

a rateable value system with a slightly higher running charge, say of 1d. per unit.

"The Point Fives" Association as a body holds the opinion that no great headway can be made in the supply of electricity for heating, cooking, and other domestic purposes, apart from lighting, at any price exceeding ½d. per unit, in districts in which gas is sold at 2s. 6d. or under per thousand cubic feet. In Bradford and Sunderland the fixed charge arrived at on a rateable value basis has been so calculated that, plus a charge of ½d. per unit for current used for lighting purposes as registered by meter, it is on the average equal to the cost of lighting a house moderately well throughout at between 3½d. and 4d. per unit. It follows, therefore, that on the average all units sold for heating and cooking purposes, and any increase of illumination above the ordinary, are obtained by the consumer at a flat rate of ½d., and it was to the results of selling current for these purposes at a flat rate of ½d. that the attention of the members of the Incorporated Municipal Electrical Association was primarily intended to be drawn, whereas by most of the speakers these results have only been given a secondary place, if mentioned at all, and the pros and cons of the rateable value system have provided the main theme of the discussion. Several speakers revived a jibe which has on a number of occasions been made at the expense of "The Point Fives," both verbally and in the press, to the effect that a member of this Association was one who, while contending that he sold electricity at ½d. per unit, in reality sold it at an average price of between 1½d. and 2d. The makers of such statements are simply raising a bogey for the purpose of knocking it down, as, as far as the writer is aware, no member of "The Point Fives" Association has claimed to supply electricity for *all* domestic purposes at a flat rate of ½d. per unit or less. The majority of the members, however, do claim to be selling electricity for heating and cooking purposes at ½d. per unit, whether their tariff is based on the rateable value system or on a flat rate for lighting and a separate flat rate for heating and cooking. If the average rate paid by all domestic consumers for the whole of the electricity consumed by them for lighting and other domestic purposes is calculated out, it must naturally be considerably higher than ½d. per unit, owing to the higher prices which are charged for the lighting units. It would be equally as sensible to maintain that an engineer who charges a consumer a flat rate of 1d. per unit for energy supplied for power purposes does not supply electricity at 1d. per unit, owing to the fact that as the same consumer

takes a large lighting supply at 4d. per unit, the average charge made for lighting and power purposes combined may exceed 2d. per unit.

In opening the discussion Mr. Wilkinson called attention to the Table on page 14 of the Report, and deduced from the same that although a Point Five Tariff causes a very healthy increase in the number of units sold, the effect upon the revenue of the undertaking is anything but healthy. As several other speakers emphasised this point, the authors think it as well to clear up a misunderstanding which has arisen in respect to these figures. In putting forward this Table and a similar Table applying to the Sunderland undertaking, the authors wished to show the effect of a Point Five Tariff on consumers who had previously been supplied under the tariffs existing prior to the adoption of the new method of charging. On page 13 of the Report it states that, "Owing to changes of tenancy and alterations in other conditions, the comparison given below relates to only 138 of the consumers changed over, the periods covered being the year prior to the introduction of the Point Five Tariff and the year ended 31st December, 1914." As the consumptions of these consumers increased by 94·9 per cent. under the new tariff, it is very clear that the tariff encourages consumers to increase their consumptions of electricity, and it has been ascertained that the additional units were mostly consumed by reason of the use of heating apparatus. With regard to the falling off in the revenue derived from the 138 consumers, this is only what might be, and, in fact, was expected. As pointed out by Mr. Wilkinson, only the consumers who would benefit by the introduction of an alternative new rate would take advantage of it. It is hardly likely that the 138 consumers in question, having the option of remaining on the flat rate of 4d. or of changing over to the domestic rate of 15 per cent. on the rateable value and ½d. per unit, would have changed over to the latter without they saw some definite advantage would be gained by so doing. In some cases the only advantage was that they could obtain current for heating purposes at a low rate, but in the majority of cases a direct reduction was effected in the cost of their lighting supply. The Table, however, makes it very apparent that, in the case of Bradford at any rate, there is no foundation for the suggestion that a Point Five Tariff under the rateable value system is a means of deluding the undertaking's consumers into believing that they are getting a substantial reduction and current for heating and cooking purposes at a low rate, whereas in reality they are not.

It should also be pointed out that when the domestic tariff was instituted at Bradford, it was fully realised by the Electricity Committee that the time had arrived for a reduction to be made in the charges to domestic consumers who had wired their houses throughout or practically so, and consideration was given to the lines upon which such reduction should be made. Such consumers were, as previously stated, at the time being charged on a flat rate of 4d. per unit, and it was obvious that if a flat rate was retained and a reduction made to 3½d. or 3d. per unit, all consumers would benefit irrespective of the amount of current consumed or the load factor. By adopting the rateable value system, the good consumers were put in a position to obtain the necessary reduction, and little or no reduction was allowed to consumers with poor load factors. Encouragement was given to the latter to increase the size and use of their installations, and to all domestic consumers to utilise electricity for heating and cooking purposes. Had the Committee adopted the same course as has been pursued in a number of towns, and reduced the price to 3d. per unit, the revenue received from the 138 consumers mentioned in the first Table on page 14 would have been reduced from £1,566 to £1,174. As shown by the Table the revenue actually obtained was £1,358. The result, therefore, as regards the 138 consumers was almost identical with what it would have been had the flat rate for lighting purposes been reduced from 4d. to 3d. per unit and these consumers used exactly the same amount of current for lighting purposes, and the 94·9 per cent. increase in their consumptions—equal to 88,992 units—had been sold them for heating and cooking purposes at ½d. per unit. These consumers, however, are naturally better off under the Rateable Value Tariff, as a certain proportion of the increased consumption has been used for lighting purposes, for which under the above-mentioned double flat rate system they would have been charged 3d. per unit.

The revenue of the undertaking has, in addition, not suffered to the extent it would have done under flat rates of 3d. for lighting and ½d. for heating and cooking purposes, as the consumers whose residences are only partially wired and/or the load factors of whose installations are low have not received an undeserved reduction of 25 per cent. on their accounts.

The Table at the bottom of page 14, which was either overlooked or ignored by the various speakers who were alarmed at the results set forth in the Table at the top of the page, gives a much better indication of the results of the working of the Point Five Tariff. In this case the comparison applies to all

domestic consumers connected for the complete twelve months ended 31st December, 1914, and shows that the average number of units consumed per house in the case of consumers on the flat rate was 367 and the average revenue £5 18s. 0d., as against an average number of units per house of 1,082 and an average revenue of £7 12s. 4d. in the case of the consumers on the Point Five Tariff. There is little doubt that consumers on the flat rate are using electricity for lighting purposes only, and, therefore, those on the Point Five Tariff are consuming on the average 715 additional units per house either for increased lighting or for heating and cooking purposes. The average revenue obtained for the additional 715 units is £1 14s. 4d., so that the average price per unit obtained for the additional current sold is ·575d. Taking into consideration the very small additional capital outlay involved, and the fact that the total running costs and expenses due to management are but slightly increased, in the writer's opinion the result is very satisfactory. Had there been no desire to give a reduction to consumers with good load factors, but simply to give these consumers an opportunity of increasing the amount of illumination in their houses and to use heating and cooking apparatus, it would have been an easy matter to have met these conditions by making the fixed charge a higher percentage of the rateable values of the premises. Had this been done in Bradford, there is no doubt that the figures in the Table at the top of page 14 would have appeared more favourable, but, on the other hand, the Table at the bottom of the page would certainly have shown very different results.

The figures given by Mr. Wilkinson showing what would be the likely effect of the adoption by Harrogate of a Point Five Tariff, based on 15 per cent. of the rateable value, are very interesting. It is necessary, however, for Mr. Wilkinson to consider carefully as to whether 15 per cent. on the rateable value is a reasonable fixed charge to make in his town. The rateable value of property differs greatly in different towns, so that it is quite possible that a charge of 15 per cent. in Harrogate would be equivalent to a charge of 20 per cent. or 25 per cent. in Bradford, or, on the other hand, it might be equal to a charge of less than 15 per cent., but as Harrogate is a fashionable residential district the writer thinks this very unlikely. If the method adopted by Bradford for ascertaining the percentage the fixed charge should bear to the rateable value of residences was followed, providing that *all* the present residential consumers elected to be charged on the new rate, the total amount of the fixed charges, plus ½d. per unit for all lighting units consumed,

would be equal to the revenue at present being received from such consumers under the existing methods of charging.

Mr. Wilkinson's remarks with regard to the heating of water by electricity are well worth careful consideration, as in the writer's opinion the possibilities of electricity in this direction are far from generally realised.

Councillor Dymond's comments as to large supplies of electricity being immediately demanded by upper class residential houses for heating and cooking purposes in the event of a Point Five Tariff being adopted, with consequent overloading of the mains, were ably dealt with in the contribution to the discussion made by Alderman Smith of Barrow. The following figures as applying to Bradford will show that the experience in that city is similar to that at Barrow. The 566 Point Five consumers supplied throughout the complete year ended 31st December, 1914, may be divided up in accordance with the rateable values of their residences as follows :

Rateable Values.	Number of Consumers.
Exceeding £10, but not exceeding £20 - - - -	124
,, £20, ,, ,, £30 - - - -	190
,, £30, ,, ,, £40 - - - -	92
,, £40, ,, ,, £50 - - - -	62
,, £50, ,, ,, £60 - - - -	46
,, £60, ,, ,, £70 - - - -	19
,, £70 - - - - - - - -	33

From this it is clear that well over 50 per cent. of such consumers reside in premises having rateable values of £30 or less, which are naturally those of middle-class consumers.

Mention was made by Councillor Dymond of the large number of gas cookers and fires in use in Hereford, and he seemed to be afraid that if electricity was supplied at a low rate for heating and cooking purposes the Gas Department would suffer, and that, taking the two Departments together, the result would be a net loss to the Corporation. If the Bradford experience is any criterion, he will probably find that the persons who adopt electric heating and cooking are not at the present time using gas, but coal, for these purposes, as they have a rooted objection to the use of gas for any purpose whatever.

The writer agrees that the supply of electricity for heating and cooking purposes presents a difficult problem in a small residential town. It must, however, be recognised that if a

satisfactory half-watt lamp of moderate candle-power makes its appearance, as is likely to be the case, the revenue received by all undertakings for current supplied for lighting purposes will be considerably reduced, and the undertakings in residential districts will be far more badly hit than those relying chiefly upon power supplies for their incomes. The only way in which such districts can make up this loss in revenue appears to be in the direction of increasing their outputs for other domestic purposes. The problem has, therefore, to be tackled sooner or later, and in the opinion of the writer it is better to face it now and obtain some very necessary experience, rather than to wait until the reduction in the lighting output is an accomplished fact. A tariff of 1d. or ¾d. per unit for heating and cooking purposes, in accordance with the price charged for gas in the district, might be adopted, and the results of such a tariff would no doubt form a valuable basis on which to decide whether still further reductions could usefully be made. As far as his experience goes, however, even were a Point Five Tariff to be instituted at once, no such rush of applications for supplies for heating and cooking purposes would be experienced as many persons seem to anticipate.

This speaker contended that a tariff should possess three principal virtues: firstly, it should produce a profit; secondly, it ought to deal with absolute fairness as between consumer "A" and consumer "B"; and, thirdly, it should be able to be applied, if not to all consumers, at least to the largest proportion of them. There is no reason whatever why a Point Five Tariff, in many towns in this country at any rate, should not fulfil these conditions.

The statement made that St. Marylebone is the only Point Five undertaking which has not adopted the rateable value system, but has the kilowatt maximum demand system in operation, is totally incorrect. Both Poplar and West Ham are also working on the kilowatt demand system, and Southampton, Luton, and Wakefield have adopted a flat rate of ½d. per unit for heating and cooking purposes. Councillor Dymond makes the same mistake as many other speakers in confounding the rateable value system with the Point Five Tariff. It is quite possible that the rateable value system would not prove suitable in all towns, and as such good results have been obtained in Hereford under the maximum demand system of charging, and the consumers there—unlike those in many other towns—appear to understand the working of this system so well, the writer would suggest that a Point Five Tariff on the maximum

demand system should be adopted in connection with that undertaking.

The statement that the rateable value system lends itself to the production of a tariff which lands the undertaking into a loss is certainly not borne out by the experience gained in Bradford, and must astonish those in control of the very large number of undertakings in the country which charge on this system and yearly show most excellent results.

Mr. Wordingham also appears to be under the delusion that the Rateable Value system and the Point Five Tariff are one and the same thing, as he states that "The Point Fives" Association have re-discovered the "Hopkinson" system and are bringing it forward and advocating it for all it is worth. The reply to this statement is that neither the Association nor any of its members takes credit for the introduction of the Rateable Value system, but some members have applied the system—which had already proved its merits—to their own needs. In addition to this, at least three members are supplying current for heating and cooking purposes at a flat rate of ½d. per unit, and are, therefore, apparently quite opposed to the "Hopkinson" method of charging. This speaker's point as regards the Point Five Tariff at Bradford being 1¾d. has been dealt with earlier in the reply.

Mr. Wordingham asked the question as to how the following case would be dealt with:—Supposing that a consumer who is charged on the Rateable Value system has a very bad load factor, and that the average charge on this system works out at 2s. 6d. per unit, is it legal to make such a charge? Providing the total amount of the consumer's account is in excess of the minimum amount which the undertaking is authorised, in accordance with the terms of its Provisional Order, to charge for any consumption up to a certain number of units, the writer does not think it would be legal to charge an average of 2s. 6d. per unit, or that any well-managed undertaking would desire that it should be, as the duty of supply authorities is to serve the public, not to rob them.

He is in total disagreement with this speaker's dictum that the figures given in the paper clearly showed that a system could not be right which nearly doubled the consumption and yet reduced the revenue. The paper certainly showed that in the case of 138 consumers, in the aggregate the effect of the tariff was increased consumption and reduced revenue, but the result taking all residential consumers into account is that the undertaking has very considerably increased its revenue,

and the revenue per house received from consumers on the Point Five rate is nearly 30 per cent. more than that received from the flat rate consumers. Any substantial reduction in a tariff is almost certain largely to decrease the revenue derived from and to increase the consumption of existing consumers, but the loss in income in respect to such consumers is usually more than made good by additional revenue obtained from new consumers gained. Had not this fact been generally recognised by the managers of electricity supply undertakings, the charges for electricity throughout the country would probably still be about the same as they were in the antediluvian days which Mr. Wordingham knows so much about. The policy which has been pursued by Bradford, Sunderland, and other towns is on all fours with that of a great daily newspaper—the proprietors of which have probably never, even by their bitterest enemies, been accused of want of business acumen—which recently reduced the revenue derived from existing readers by well over 50 per cent., with the object of increasing the paper's circulation and the total revenue obtained.

The point raised with regard to the likelihood of a consumer doubling or trebling his maximum demand for lighting purposes is fully dealt with on pages 10 and 11 of the paper.

The speaker also stated that he did not believe for one moment it was possible to heat water by electricity economically in sufficient quantities for ordinary domestic supply, and that it was a great mistake to try to do it or to say that it could be done. Whatever he may believe, it is a fact that a number of electric water heating installations are at present in use, are giving satisfaction, and are proving economical. Even if this were not the case, the writer is at a loss to know why it is a great mistake to try to do it. Had the pioneers of the electrical industry been imbued with similar ideas, instead of faith in the future of electricity and courage to tackle the apparently impossible, electricity supply undertakings would probably be non-existent to-day.

With regard to the opinion expressed that it is wrong to increase the capacity of radiators in order to heat the air of the room in which they are installed, and that it is essential to keep the air cool, and warm the individual, this, though it may be scientifically correct, is not the opinion of the great body of consumers who have to be catered for. Whatever form of heating is adopted, the usual practice is to warm the air of the room until it reaches a temperature of about 60° Fahr., and one finds it very difficult to persuade a person that he should sit in a

room having a temperature somewhere near freezing point—as is the case on many winter days—and toast a portion of his anatomy by the rays of a one-kilowatt radiator, leaving the other portions to freeze, it being usually difficult, if not impossible, to arrange for such a person to be surrounded by radiators.

Mr. Lackie's opening remarks, both as regards the contention that energy is not supplied by members of "The Point Fives" Association at ½d. per unit, and as to discrepancies in the figures given on page 14, have been dealt with earlier in this reply. Mr. Lackie pointed out that before fixing the Glasgow tariff his main endeavour had been to see that the revenue per house was increased and not diminished. This was also the endeavour of the writer, providing that the increase was due to the installation of additional lights or of heating and cooking apparatus, and the table at the bottom of page 14 of the paper shows that the endeavour has met with success. With regard to lighting supplies only to residences wired throughout and with good load factors, there was a definite intention to reduce the revenue obtained. An example was given by the speaker of a charge made under the double flat rate in operation in Glasgow, with the object of showing that the same compared favourably with the examples of the Point Five Tariff given on page 9 of the paper. These latter examples were, however, not intended to represent fair average consumptions of houses of £40 rateable value, but were purely hypothetical cases put forward to show an advantage the Rateable Value system of charging possesses in respect to the facility for closely estimating the probable cost of electricity supply for any house. Mr. Lackie's example of what the bill of a domestic consumer living in a £40 house in Glasgow would probably be goes to indicate that while the lighting consumers at Glasgow are supplied at an exceedingly cheap rate, the heating and cooking tariff is not sufficiently low to induce consumers to use such apparatus to any great extent. It is shown that in such a house the number of units used for heating and cooking purposes would only be 400. The writer presumes that the house would be inhabited by at least three persons, and, on a very moderate basis, if electricity was used for cooking, the consumption for this purpose would average at least six units a day. One might, therefore, expect a consumption of over 2,000 units for cooking purposes alone, leaving heating entirely out of the question.

The following figures relating to a consumer at present on the Bradford supply may usefully be compared with the hypothetical

Glasgow case as showing the advantage of the Point Five Tariff:

HOUSE RATED AT £30.

On Flat Rate.—Year ended 30th June, 1910.

	£	s.	d.
244 units at 4d.	4	1	4
Meter rent	0	8	0
Total	£4	9	4

Average price, 4·39d. per unit.

On Point Five Tariff.—Year ended 31st December, 1914.

	£	s.	d.
15 per cent. on Rateable Value of £30	4	10	0
4,757 units at ½d.	9	18	2½
Total	£14	8	2½

Average price, ·73d. per unit.

It will be noted that in this actual case the average price paid by the consumer under the Point Five Tariff for electricity consumed for all purposes, including lighting, is less than the flat rate charged at Glasgow for domestic heating and cooking supply only. It is very clear that the Point Five Tariff has been the means of increasing the revenue as well as the consumption in connection with this house, also that the fixed charge is a very suitable one in this case, as the meter rent is included in it, but is an additional charge in respect of the flat rate.

The figures given by Mr. Lackie with regard to his own house would seem to indicate that he himself finds ¾d. per unit too high a price to pay for electricity used for heating and cooking, as his consumption for these purposes is only 1,200 units per annum.

The information as to houses in Glasgow which have been electrically equipped throughout is very interesting and useful as giving some idea of what the future outputs of electricity undertakings may be when the domestic load has been developed. Considering, however, that the houses have only five apartments, the revenue received, viz., £51 8s. per annum from the first house to be occupied, is extraordinary. Houses with five apartments in Bradford would have an average rateable value of not more than £15, and if the occupants were found to pay on the average £10 per year for coal and gas, the writer would be surprised. The radiators used in the Glasgow houses appear to be of very small capacity, as does also the cooker.

It is to be hoped that Mr. Lackie will at some future date give a full description of these houses, showing the arrangement and size of the rooms and details of the lighting, heating, and cooking installations, as well as particulars with regard to the load factors and the diversity factor.

Mr. Cooke appears to have obtained the impression from the returns given in the paper that the units sold for domestic purposes in Bradford are about 185,000 per annum ; this, however, is not the case. For the year ended 31st March, 1915, the total number of units supplied to domestic consumers under the Point Five Tariff was 797,303. The writer quite agrees with Mr. Cooke that there is a vast field for heating supply in connection with business premises, and hopes that before long a Point Five Tariff will be available for such premises in Bradford.

Mr. Nichols Moore maintained that progress in the supply of current for heating and cooking purposes could be made with a tariff of 1d. per unit. The writer does not think that any member of "The Point Fives" Association will disagree with him, as practically all have had experience with a 1d. or ¾d. rate prior to adopting a Point Five Tariff. To compete seriously with other methods of heating and cooking, however, they are of the opinion that the tariff must be reduced to ½d. His remarks regarding the Bradford results have been replied to earlier. As to the results of the working of the tariff in the other Point Five towns mentioned, the writer is not in possession of the necessary statistics concerning these undertakings to enable him to meet Mr. Moore's arguments, but he has no doubt that the engineers of the undertakings referred to could show very good cases for the policy adopted by them.

Mr. Long asks how a Point Five Tariff can be justified in the case of towns in which the cost of coal per unit is in the neighbourhood of ½d. This question can only be satisfactorily answered by the engineers of the towns concerned. The writer would, however, remark that when fixing the amount to be allocated to standing and running costs under any tariff, it is usual for at least 25 per cent. of the coal costs, and considerably higher percentages of other items making up the works costs, to be debited to standing costs (*see* Report of Joint Committee of M.T.A. and I.M.E.A. on Charges for Electrical Energy supplied for Traction Purposes from Combined Stations). If only 25 per cent. is taken off the figures given with regard to the average cost of coal per unit in the towns mentioned, the charge of ½d. per unit will compare much better with the coal costs. It must also be remembered that the coal costs quoted are average costs,

and that the cost of generating units during the hours of light load is very much higher than during the heavy load periods. In works supplying residential districts the number of hours of light load is very high compared with the number of hours during which a moderately good load is sustained. The supply during the hours of light load is usually provided by small inefficient generating sets or by large generating sets run at an uneconomical load. If, therefore, by selling electricity at a cheap rate for heating and cooking purposes, a good day load can be obtained, not only is the cost of generation reduced during the hours of light load, but the average figures per unit in respect of each item of works costs may also be appreciably lowered.

The writer has not referred in this reply to the remarks of a number of speakers who took part in the discussion, owing to the fact that their contributions consisted chiefly of arguments for or against the rateable value system of charging, which, as he has before pointed out, is not a necessary concomitant of a Point Five Tariff. Others made points which have already been dealt with in this reply, and in some cases, as he is more or less in agreement with the remarks made, there is no necessity for him to comment on them.

In concluding his reply the writer would say that if the preparation and discussion of this Report lead to increased efforts being made by electricity supply undertakings to cope with the problem of electricity supply for heating and cooking purposes, the result will be a cause of gratification to the members of "The Point Fives" Association.

Mr. A. S. Blackman (Chief Electrical Engineer, Sunderland), who also briefly replied, said that the discussion had not taken the lines he had hoped, and it had rather gone to exemplify the truth of the old saying that any case could be killed with talk. Mr. Wordingham had said that no system could be right which doubled the output, and at the same time reduced the revenue. That was a very sweeping statement, and he did not think that many people would agree; certainly he did not for one. No one had ever contended that the system was all right for all towns. It was entirely a question of local conditions. His own undertaking was in the fortunate position of having a big industrial load, and the effect of this domestic supply on the generating plant was almost negligible.

On the motion of the Chairman, a hearty vote of thanks was accorded to the authors of the paper.

THE ELECTRIC VEHICLE COMMITTEE, 1915-1916.

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Hon. Secretary—F. AYTON. *Hon. Treasurer*—J. CHRISTIE.

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Representing Chelsea Electricity Supply Co., Ltd :—

P. STILL.

Representing Municipal Tramways Association Inc. :—

A. R. FEARNLEY, General Manager, Sheffield Corporation Tramways.

Representing Institution of Municipal and County Engineers :—

A. E. COLLINS, City Engineer, Norwich.

Representing the Tramways and Light Railways Association :—

A. de TURCKHEIM.

REPORT PRESENTED BY THE ELECTRIC VEHICLE COMMITTEE

ON

"The Use of Electric Vehicles in Municipal Service."

By F. AYTON, M.I.E.E.

Hon. Secretary to the Committee.

THERE could hardly be conceived a more suitable field for the employment of the electric battery vehicle than that connected with Municipal service. This is because the work to be done lies entirely within the proper sphere of this particular type of vehicle, viz. : short distance haulage at moderate speeds. The mileage capacity per charge, *i.e.*, 35 to 45 for the heavier vehicles, is sufficient for practically every duty which the Municipal vehicle has to perform, but it must not be forgotten that, by a mid-day boosting charge, the daily mileage may be considerably increased. In fact, the only limit to the daily mileage is the time required to charge the battery, and, as the modern types of battery allow of the charging being commenced at a comparatively high rate, the time taken, especially for boosting charges, is very materially reduced from the period which used to be considered necessary. As an instance of the amount of work the electric vehicle is capable of performing, the electric street watering and sewer flushing

vehicles belonging to the City of Calgary in Canada are reported to be in use for a 16-hour day at certain periods of the year, the Superintendent of street cleaning stating that each vehicle had replaced five horse teams with a resultant saving in expense of no inconsiderable amount.

Naturally the main reason for urging the adoption of electric vehicles by municipalities is the degree of economy which attends their use in substitution for horse haulage.

FIG. 1.—ELECTRIC WAGGON CLIMBING A HILL OF 1 IN 4 IN HAMPSTEAD.

Wherever the electric has been employed in its legitimate sphere, the claim of economy has been proved to the hilt. In citing evidence in support of this statement attention may be directed to the experience of that progressive city which can lay claim to being one of the pioneers in the municipal operation of the electric vehicle, *i.e.*, Glasgow—where the Electricity Department found that their first electric van, of 1 ton capacity, did the work of two horses

at a saving in expense and with greater efficiency, while, compared with a petrol van, which the Department was previously using, the electric did the same work with a saving in expense in the neighbourhood of £240 per annum. Other evidence is afforded by the refuse collection trials at Barnes and at Heston and Isleworth, referred to in detail later, while the instance of Calgary, previously mentioned, provides an additional illustration of the financial advantages accruing from the employment of this type of road motor, the daily saving, as against horses, by the operation of two watering and flushing vans, being given as about £5. Outside Municipal service we have the case of the electrified delivery service in London of Messrs

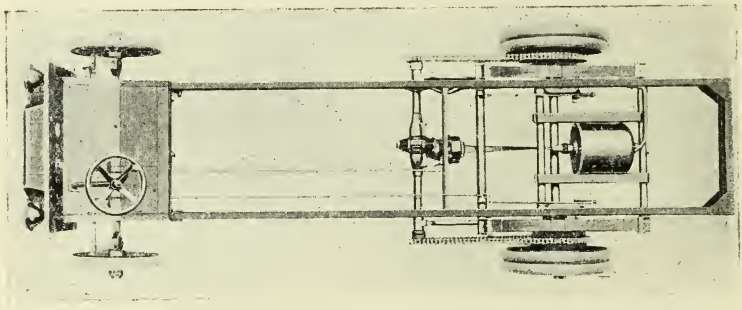


FIG. 2.—A TYPICAL ELECTRIC VEHICLE CHASSIS SHOWING CLEARLY THE SIMPLICITY OF THE MECHANISM.

Harrod's Stores. This firm now operates no less than 55 delivery vans, and they state to your Committee, as their reason for adopting the electric vans : " We find them cheaper than horses."

The durability of the electric vehicle is a feature not to be lost sight of, and there is ample evidence, based upon experience, that there is justification for putting the average life of a modern vehicle of good make at not less than ten years, assuming reasonable use and proper upkeep. In the United States electric commercial vehicles built twelve years ago are still in daily service and many seen in the streets

are well over six years old. A large American firm of goods carriers, having depôts and delivery vehicles in all the principal cities, wrote to the Committee last year in regard to their experience with electric vehicles, stating, among other things, that "the first cars purchased in 1904 and 1905 are still in daily operation without unreasonable expense or unduly high charges." This company owns no less than 375 "electrics."

Reliability is another feature of the electric vehicle which must not be overlooked for experience has shown that this type of automobile can keep the road day by day for more days in the year than any other type—in fact records show that it is safe to estimate, in the case of a fleet of electric vehicles, that the average working days in a year for each machine will be not less than 97 to 98 per cent. of the maximum possible. The reasons for this are three-fold; firstly, the simplicity of the mechanism; secondly, the

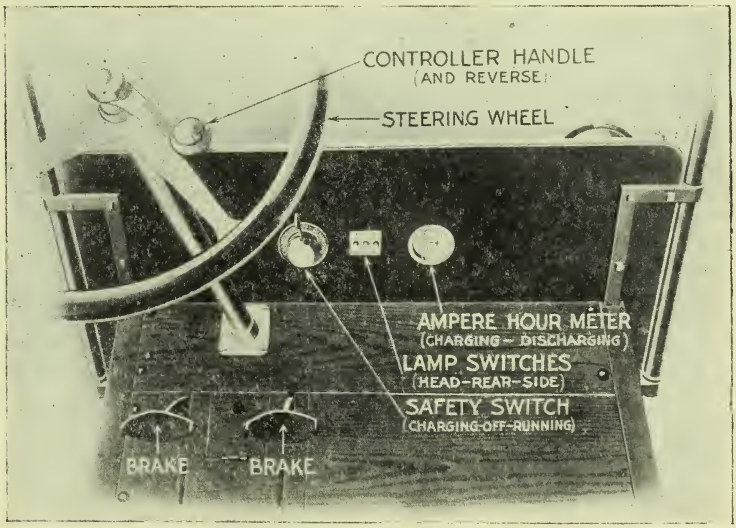


FIG. 3.—THIS ILLUSTRATION OF THE DASH OF AN ELECTRIC VEHICLE INDICATES THE SIMPLICITY OF THE CONTROL GEAR.

strong construction possible on this account, and, thirdly, the fact that, owing to the simplicity and fewness of the working parts, any repair or replacement can usually be effected during the night, or in such a short time as not to interfere with the use of the vehicle. The net effect of all this is that, where several vehicles are operated, fewer spare ones need be kept than if petrol or steam machines were employed.

While economy in cost of operation should undoubtedly be considered an important factor in determining the system of haulage to be employed, a Municipality should not lose sight of the influence that the use of any particular type of vehicle may have upon the health of the population and the amenities of the locality. It may be said, in reply to this assertion, that the vehicles which the Municipality will employ are, or will be, so few, by comparison with the total of motor vehicles in use, that whatever good or bad features the type adopted may possess in the two directions mentioned, it will make no difference. So much may be granted, but it can be urged with justification that it is the duty of a municipality to set a good example in everything it undertakes. As a general rule it may be said that in the treatment of their employés, for instance, the municipalities of this country set a good example to all other employers of labour. Is there any reason, therefore, why the same broad principle should not guide them in the selection of a system of haulage? Good and useful as the horse has been, the principles of modern hygiene dictate that its continued use in congested areas is incompatible with the preservation of the best health among the populace and the maintenance of the lowest possible rate of mortality. The place of the horse has, in future, to be filled by the self-propelled vehicle, and the type which is going to eventually supersede it is that vehicle which will do the same work at the same or a lower cost and which, besides, will be characterised by silence in operation, general cleanliness and absence of odour, ease and simplicity of control, rapid acceleration, and safety in regard to the risk of fire.

The electric vehicle is the only automobile taking the road to-day which meets fully each and every one of these requirements. It is safe to say that were the self-propelled vehicles operating in London, and other large centres, of the electric battery type, those places would, to-day, be very much pleasanter and healthier to live in. Here then is the opportunity for the Municipalities to lead the way in regard to an improved means of locomotion the advantages

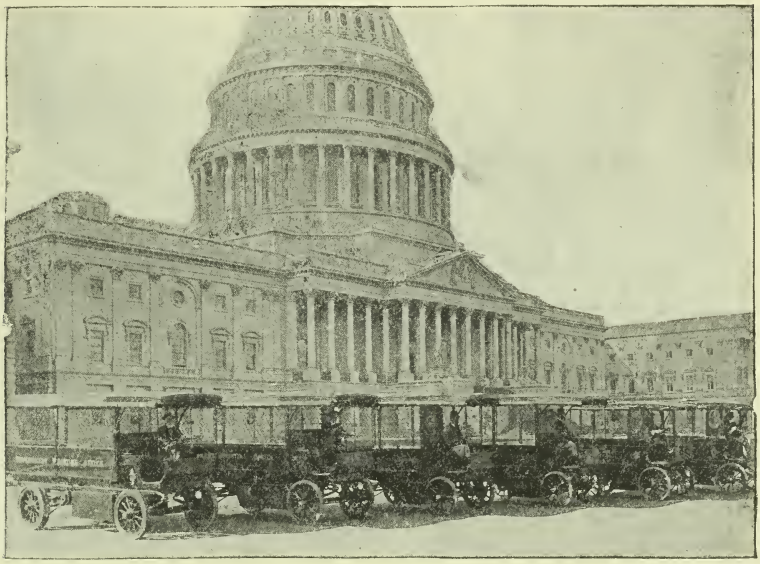


Fig. 4.—Electric Vehicles belonging to the Government Printing Office, U.S.A.

of which are fully established. The modern electric battery vehicle is no mere experiment; its utility and reliability, as well as its unique economy, are attested by the fact that upwards of 70,000 of the type are in use in the United States where, within the last few years, there has been an enormous growth in the numbers put into service. The advantages which the type possesses from the point of view of public health and civic amenities are alone sufficient to warrant its adoption by municipalities. In the case

of those municipalities that own electric supply undertakings, there is a further and very pertinent reason why they should set the example as users, and that is the important new source of revenue which the general use of electric vehicles in any district will open up. And the value of this additional source of revenue is emphasised by the fact that the demand in connection with it need never come on during " peak-load " hours ; hence it may be dealt with without requiring additional expenditure in plant, buildings or mains. Moreover, as its effect will ever be to even out

FIG. 5.—ELECTRIC VEHICLES CAN BE CONSTRUCTED FOR THE LARGEST CARRYING CAPACITY WHICH PERMISSIBLE WHEEL LOADS ALLOW. THIS ILLUSTRATION SHOWS A 5-TON DRAY IN THE SERVICE OF AN IPSWICH BREWERY. IT UNDERTAKES JOURNEYS OF 24 MILES THERE AND BACK INTO THE COUNTRY DISTRICTS.

the load curve and so lead to greater economy in the cost of generation, this will, in time, permit of a lower rate being charged to all other classes of consumer. Cheap electricity for all purposes should be the persistent aim of every Municipal electrical undertaking and the cultivation of the vehicle charging load is a step on the way.

We may now proceed to consider with what advantage electric vehicles may be adopted by the different departments over which the activities of Municipalities are generally spread.

The Electric Supply Department.

It has been pointed out above how valuable is the revenue to be obtained from the charging of electric vehicles, and surely a consideration of it should be an incentive to employing every possible means to building up that class

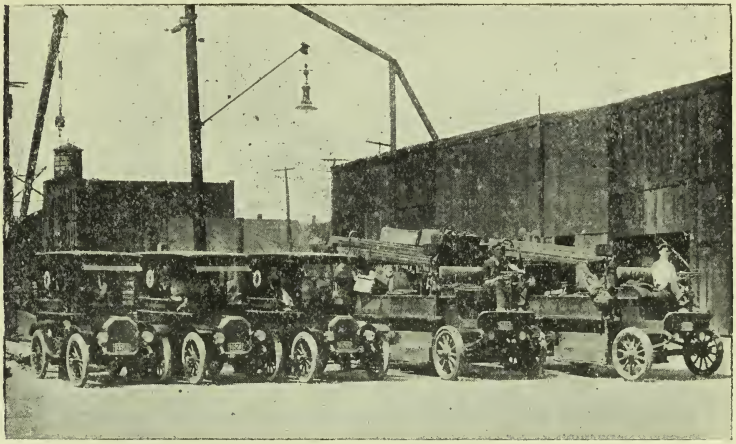


Fig. 6.—An American Electric Supply Co.'s Fleet of "Electrics."

of business. What would be thought, to-day, of an electric supply undertaking that lighted its generating station and offices by gas? And yet that state of affairs, if it existed, would be just on a par with the undertaking which wants the electric vehicle business and yet continues to employ horse haulage, and in some cases petrol motor transport for its own work. How can any central station hope to induce the adoption of the electric vehicle in its territory unless it first sets the example? And a very short experience of the employment of a suitable "electric" for the outside

work of an electric supply department of any size will soon make an enthusiast of any engineer. Apart from its splendid advertising value and its usefulness for giving demonstrations, it has many other advantages of special value in this field of employment. For breakdown work it will soon be found invaluable—it is ready to go out at a moment's notice, and is so simple to drive that several of the mains staff may be taught to operate it in order that there shall always be a driver available. The permanent driver can be a mere youth. There is an advantage in having one who

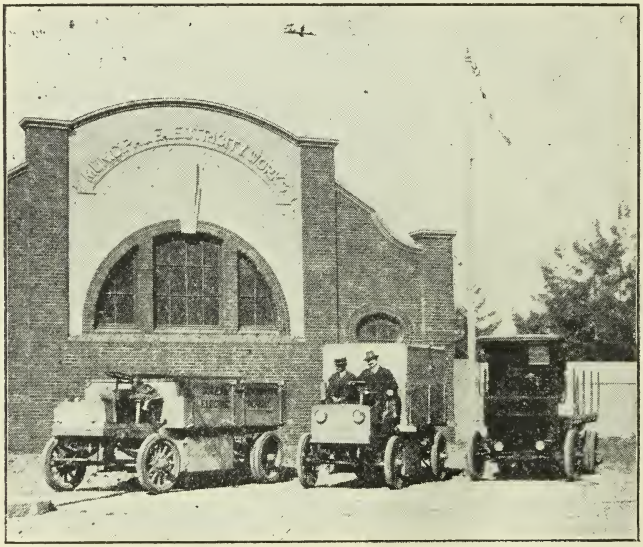


Fig. 7.—The Fleet of "Electrics" belonging to the Electric Supply Dept., Durban, Natal.

is just old enough to be eligible to hold a licence because that, in itself, attests to the ease of control and the simplicity which is so valuable a feature of the vehicle. There are few, if any, undertakings of reasonable size that could not make good use of a half-ton or one-ton van for delivering meters, transporting materials to the service and mains-laying gangs, and in other like duties. And in the larger

undertakings good use may be made of a small electric car for the business rounds of the engineer, the mains superintendent or the sales manager.

Delivery vans are now in use or on order by the Electric Supply Departments at Glasgow, Edinburgh, Derby, West Ham, Croydon, Blackburn, Bootle, Hereford, Ipswich, Grimsby, Brighton, Wolverhampton, Southampton, Liverpool, and the Borough Councils of St. Marylebone, Stepney and Poplar.

The van used by the Glasgow Electric Supply Department is a covered one of one-ton capacity, fitted with an Edison battery. The vehicle has been in constant use since the 6th August, 1913, and up to the 28th April, 1915, had covered a total mileage of 22,284 with an energy consumption of

Fig. 8.—The 1-ton Van of the Glasgow Electric Supply Dept.

13,752 units, including battery losses, which is equivalent to 0·62 unit per vehicle mile. New tyres have recently been fitted in substitution for a set which had done over 11,000 miles. The Chief Engineer of the Department, Mr. W. W. Lackie, to whom the Committee are indebted for the particulars here given, states : " The van being to some extent an experimental vehicle, the cost of maintenance and repairs includes some items which are really improvements. From the experience gained it is clear that, with a well-built chassis with proper equipment, the cost of repairs and maintenance on electric vehicles will be very low."

The result of the use of its one-ton van, in the way of economy and reliability, were so convincing that the Department had no hesitation in taking a further step in the general adoption of electric vehicles by placing an order for three more vehicles of half, one and a half, and three tons capacity respectively, which have now been delivered and will shortly be at work. The two lighter vehicles will be used for delivering material from the general store to jobs within the supply area, and to the various sub-stations, while the three-tonner will be principally employed on mains work.

The Department has fitted up a garage in which these vehicles will be stabled. The garage is complete with charging plant, and having a floor area of 10,400 sq. feet, it will permit of other vehicles being taken in for charging.

The vehicle at Brighton is a two seater car used by the Engineer and Manager of the Electric Supply Department for business purposes, including journeys to the Power Station, a little over 4 miles outside Brighton. Its speed is about 16 miles per hour on the level ; weight, 22½ cwts. ; average daily mileage 25, while the energy consumption is about 0·5 unit per mile input to battery. At 1d. per unit this is only about one halfpenny per mile. The vehicle has run close on 1,000 miles at the time of writing, and, so far,

beyond the cost of cleaning, it has cost nothing for maintenance, the tyres showing little or no signs of wear. The battery is of Tudor make.

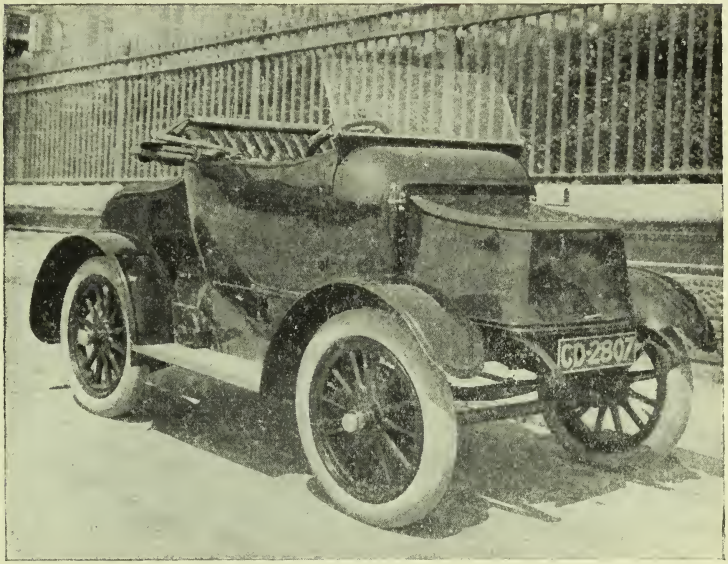


Fig. 9.—The Brighton Electric Supply Dept. Electric Car.

The West Ham Electric Supply Department's vehicle has a carrying capacity of one ton, is fitted with a float body, and is used for the general carrying work of the Department. It was put into service on the 21st November, 1914, and up to the 31st March had covered 1,788 miles with a consumption of electric energy of 0·5 to 0·6 unit per mile of input to battery. Here again we have, at 1d. per unit, a power cost of about one halfpenny per mile. The vehicle has proved of the utmost value to the Department. The battery is an A 6 Edison.

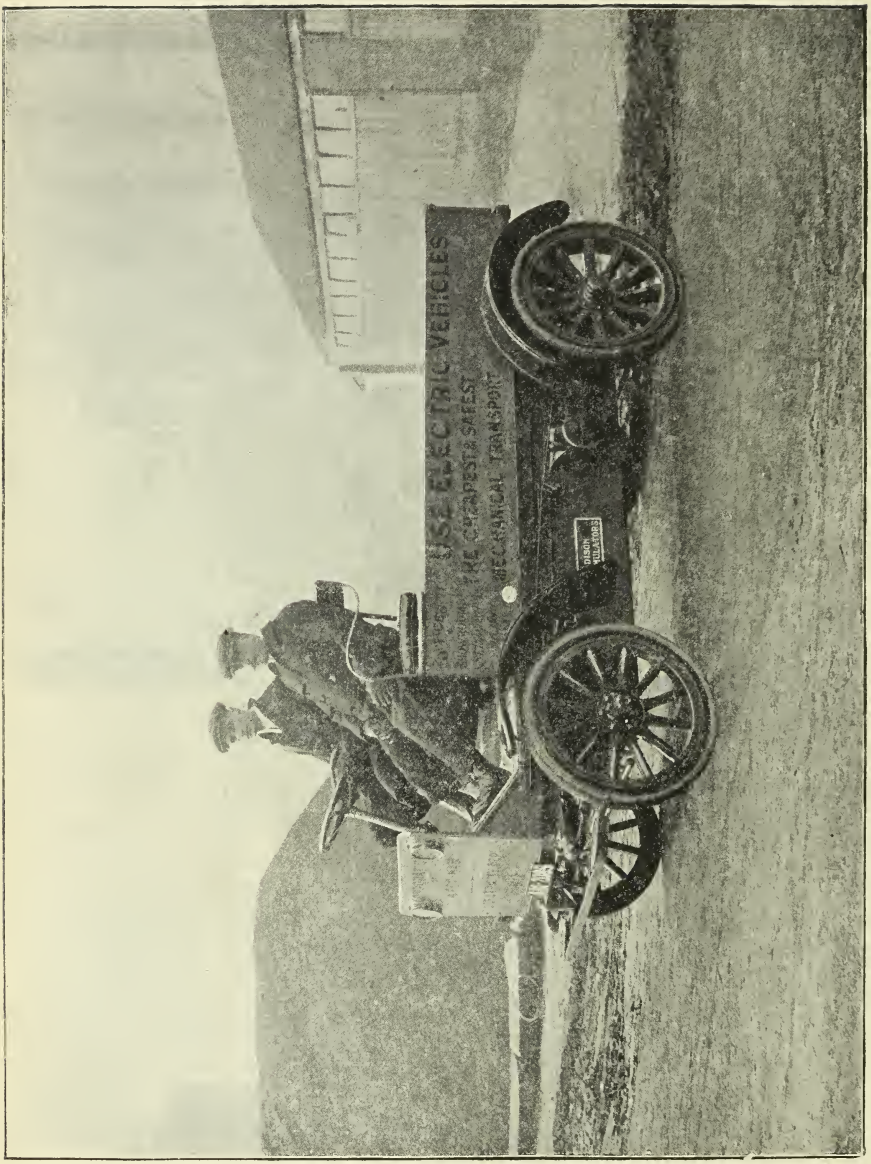


Fig. 10.—A 1-ton Electric used by the West Ham Electric Supply Dept.

The St. Marylebone Electric Supply Department van is of the covered type employed in the general delivery work of the business. It is fitted with a Hart battery. The vehicle weighs 34½ cwts. ; has a speed of about 13 miles per hour, and consumes 0·61 unit per mile. Up to the beginning of April the total mileage had been about 5,000, while the whole expense of operating it, including driver, sundry repairs, licences, insurances, etc., amounted to £68.

Fig. 11.—Electric Van of the St. Marylebone Electric Supply Dept.

The vehicle operated by the Electric Supply Department at Wolverhampton, is used for delivering goods, such as cookers, heaters and small motors, as well as to take men and their tools on to jobs. The energy consumption is 0·74 unit per mile input to battery, and the speed about

12 miles per hour. The Department has on order a 2½-ton vehicle for the removal of clinker and ash from the power station.

The Ipswich vehicle has a total weight of 34⅝ cwts., a speed on the level of about 12 miles per hour, and an energy input to the battery of about 0·7 unit per mile. A Hart battery is used. The vehicle is used for delivering the goods of the Installation Department, and is also employed by the Mains Department. It has proved extremely useful.

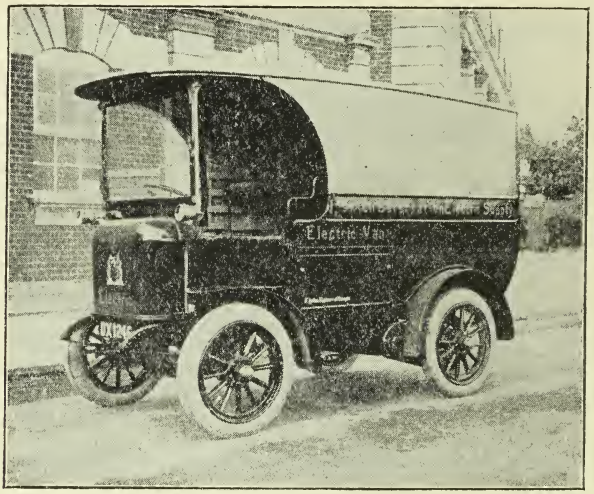
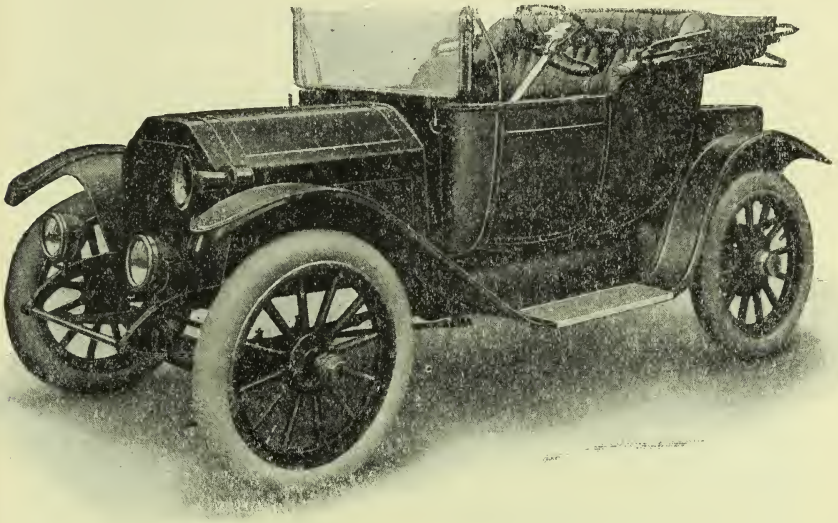


Fig. 12.—The Electric Van of the Ipswich Electric Supply Dept.

The vehicle belonging to the Croydon undertaking is a two-seater run-about fitted with an Edison battery. There is a third seat which may be used if required. The car is used by both the Distributing Engineer and the Sales Superintendent, and during the five months in which it has been in use it has given no trouble; the expenditure in repairs and general upkeep has been *nil*. The total mileage covered in this period has been 2,156 or an average of 24 miles per

day. The Borough Electrical Engineer, Mr. A. C. Cramb, gives the following interesting figures as to the cost of operation, the cost of tyres being based upon the assumption that an average of 5,000 miles will be obtained before they require renewal, there being ample justification for this assumption in view of the very small wear so far observable.



G. 13.—Electric Car as used by the Blackburn and Croydon Electric Supply Undertakings.

Running Costs.	Total cost.	Pence per mile.
	£ s. d.	
Electric energy at 1d. per unit	4 11 8	0·510
Oil and grease	0 1 5	0·007
Washing, cleaning, etc.	3 10 0	0·388
Tyres (£35 per set for 5,000 miles)	15 0 0	1·660
Total running costs		2·565d.
Depreciation.		
Battery (5 years)	14 8 4	1·600
Vehicle (10 years)	14 13 4	1·620
Total fixed charges		3·220d.
Total cost per mile = 5·785 pence.		

The daily mileage is, of course, somewhat low for such a car, being equivalent to a little over 5,000 miles per annum. A total of 10,000 miles per annum is frequently covered by petrol cars used for " about town " work ; on such a mileage the total cost per mile would be reduced to 4·175 pence.

Mr. P. P. Wheelwright, the Engineer and Manager of the Blackburn Corporation Electricity Department, reports that

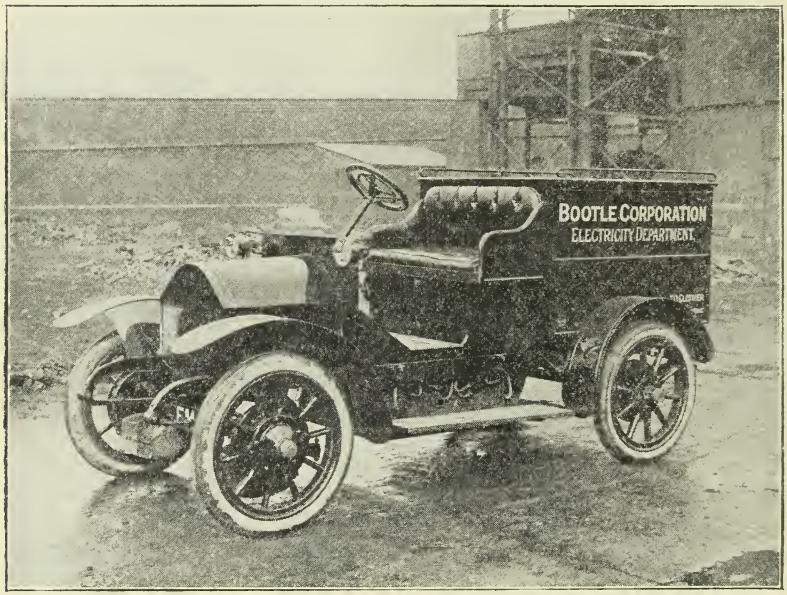


Fig. 14.—Electric Vehicle belonging to Bootle Electric Supply Dept.

their Edison passenger car, purchased two years ago, is being driven by twelve different persons, and consequently the treatment it receives is of very varying character. In cases of breakdown on the supply system, the car has been used for the carriage of material as well as men and has stood the test quite satisfactorily and well. He states, " Taking into account in the purchase of any class of car the question of

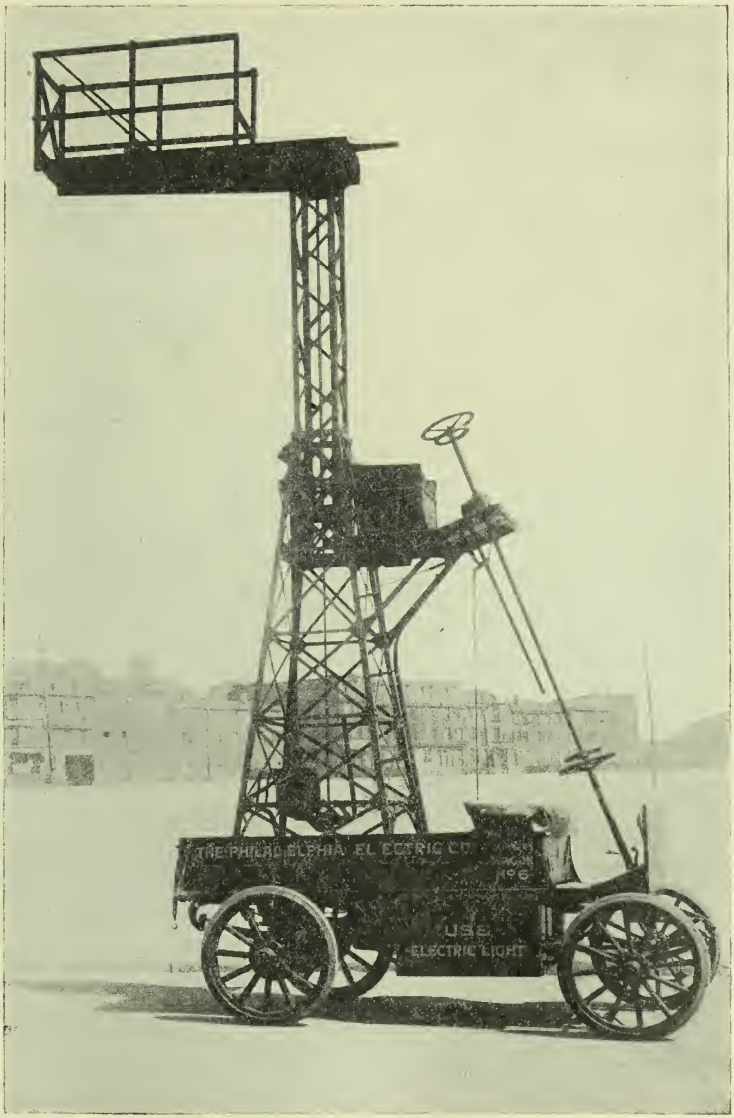


FIG. 15.—SPECIAL ELECTRIC WAGGON FOR TRIMMING ARC LAMPS, ETC., USED BY THE PHILADELPHIA ELECTRIC CO.

the work to be done, the nature of the district and general conditions to be met, there is not the least doubt in my opinion that an electric car has great advantages over other types of drive."

The vehicle used by the Bootle Corporation Electric Supply Department is driven by a motor on each front wheel, normal rating 1 h.p., each with 2½ h.p. as overload. The battery is a Tudor one of 130 h.p. capacity. It was put into service in March, 1914, and had run by the latter part of April this year 2,160 miles. The energy input to battery works out

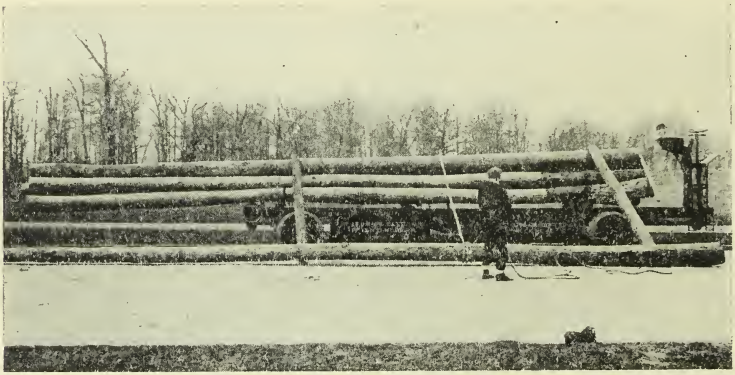


FIG. 16.—SPECIAL ELECTRIC POLE WAGGON USED BY THE PHILADELPHIA ELECTRIC CO.

at 0·79 units per mile. The total cost of operation, excluding capital charges, for the period mentioned, is as follows :

	£	s.	d.
Energy, 1,700 units at 1d.	7	1	8
Tyres	8	12	6
Sundries	3	12	10
Wages (allocated)	11	15	10
Insurance	6	7	10
Total	£37	10	8

Or cost per mile = 4·17 pence.

The car is used for mains testing, breakdown work, inspection work, calling out staff in case of emergency, etc. It is also used for emergency lighting of street pillars at night, and for this purpose has proved of great service.

Besides their use for delivering goods, answering " breakdown " calls and carrying the supervising officials about from place to place on the outside work, there are other ways in which the electric vehicle may be made use of in the service of electric supply undertakings. They may be fitted with motor-driven winch gear for use in drawing cable into underground conduits ; an electrically-operated pump may be fitted for clearing water from manholes, while a

Fig. 17.—The Electric Refuse Collecting Vehicles belonging to a Municipality on the Continent.

telescopic tower ladder can be provided for trimming arc lamps and for overhead work generally. Where a motor winch is provided, the addition of a simple derrick enables the vehicle to be employed in the erection of street lamps and trolley posts.

Where the generating station is not provided with rail or water facilities for the direct delivery of coal, so that the latter has to be carted from the railway depôt or from a wharf, an electric waggon of suitable capacity should soon

pay for itself. The same vehicle could be used for carting away ash and clinker. Considerable use is made of electric vehicles for these purposes in the United States.

In demonstration work connected with the obtaining of new business, the electric vehicle promises to be a useful aid because of the supply of electric energy which it carries with it. By the aid of a flexible cable carried through the front window of the house, from the vehicle standing outside in the roadway, the canvasser will be able to demonstrate before the housewife at home the transcendant utility of

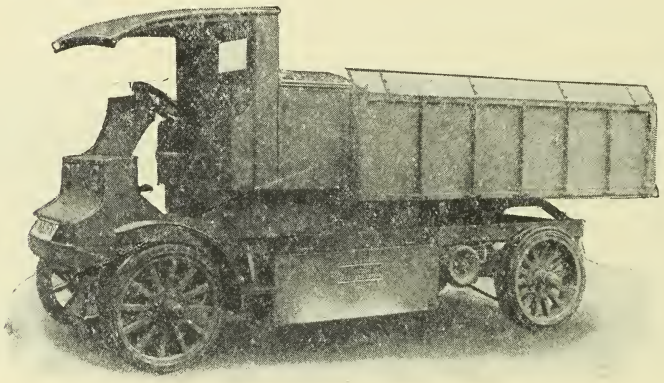


Fig. 18.—An Electric Tipping Waggon for the Collection of House Refuse.

the electric iron, the labour-saving and, no less, the hygienic value of the vacuum cleaner, the comfort and cleanliness of the electric fire, the refreshing breezes of the electric fan, the convenience of the electric kettle and the smaller pieces of cooking apparatus, while last, but not least, he will be able to show that electric light is next in quality to daylight. It needs no stretch of the imagination to conceive how potent a factor in "new business getting" will be obtained by such use of the electric vehicle.

The Collection of House Refuse.

The collection of house refuse is work which is particularly trying for the ordinary steam or petrol-motor vehicle, on account of the many stops and starts. The absence of all gear-changing and clutch work in the electric vehicle, and the uniformly easy drive produced by the electric motor, are features which establish a degree of reliability for this type of vehicle in such work, together with an economy in operation, which are impossible of attainment by any other type.

It possesses the advantages also that, when standing, no waste of power is going on such as takes place with the petrol vehicle in connection with which it is unreasonable to expect the driver to stop and restart his engine for every short halt.

There is another strong argument in favour of adopting the " electric " when the change is made from horse haulage to motor traction, viz., it is possible, when that type is employed, to utilise the horse vehicle drivers as the drivers of the new vehicles, because the mechanism is so simple and the operation so easy—in fact it is no exaggeration to say that driving an electric is no more difficult than driving a docile horse.

It should be obvious that in the replacement of horse-drawn vans or carts by motor vehicles, no matter whether they be petrol, steam or electric, the latter will show the best results where the refuse destructor is at a distance from the area of collection, the saving, of course, being in the higher speed at which the motor vehicle can traverse this distance, and its greater carrying capacity. It is quite possible, on this account, that, in some towns, the best economy might be obtainable by a combination of ordinary horse-drawn vehicles for the districts in propinquity to the

destructor, with the use of electric vans for the districts further away. Possibly in the latter districts, also, the

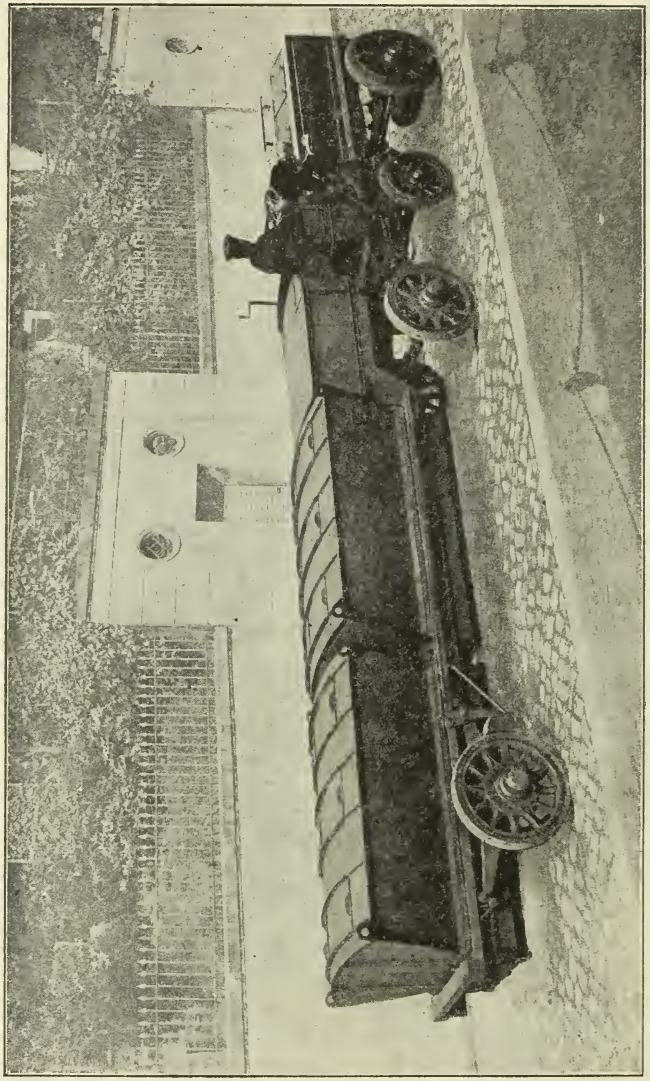


FIG. 19.—AN ELECTRIC TRACTOR HAULING SPECIAL WAGGON CARRYING REFUSE—IN THE SERVICE OF A MUNICIPALITY ON THE CONTINENT.

local collection could be best done by horse vehicles conveying the material to a central depôt from whence it would be transported to the refuse destroyer by large electric vehicles. An arrangement of this latter sort has been in successful operation in a large Continental city for some time. The horse carts are provided with removable box bodies, so that when the cart arrives at the depôt, the body is lifted off it by an electric crane, and placed upon the flat platform of a large electric vehicle, which, when it has received its full complement of these full boxes, proceeds on its journey to the destructor. In the meanwhile empty box bodies are placed upon the tumbrils which once more proceed upon their rounds of collection.

An alternative method to that described above is the employment for local house-to-house collection of a special type of small electric vehicle, with tipping box body as illustrated in figs. 19A and 19B. In this machine, which has the advantage of possessing a low body, there is no seat for

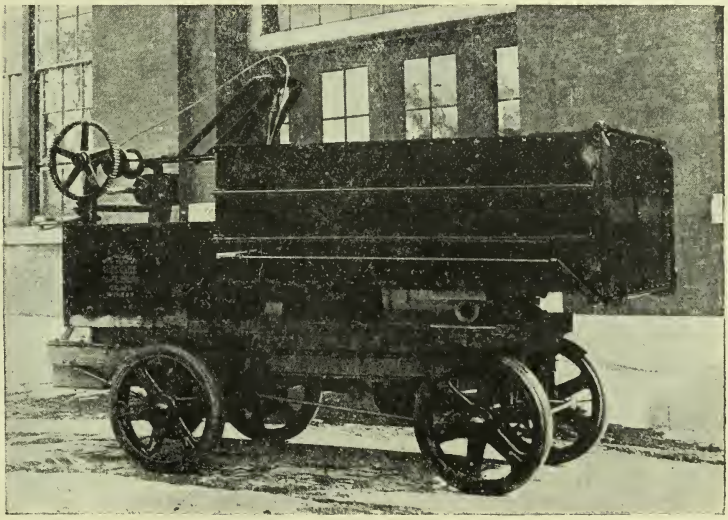


Fig. 19A.—Special Small Refuse Van.

the driver; the latter stands upon a driving platform a few inches from the ground. The saving of time in getting on and off the vehicle, when compared with the ordinary type

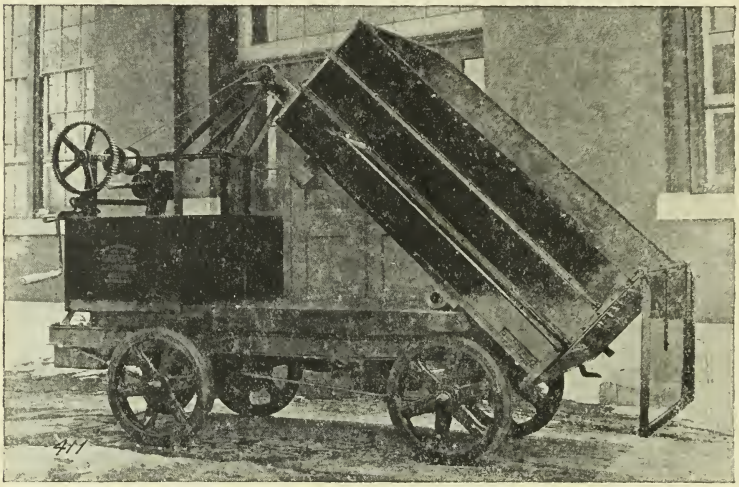
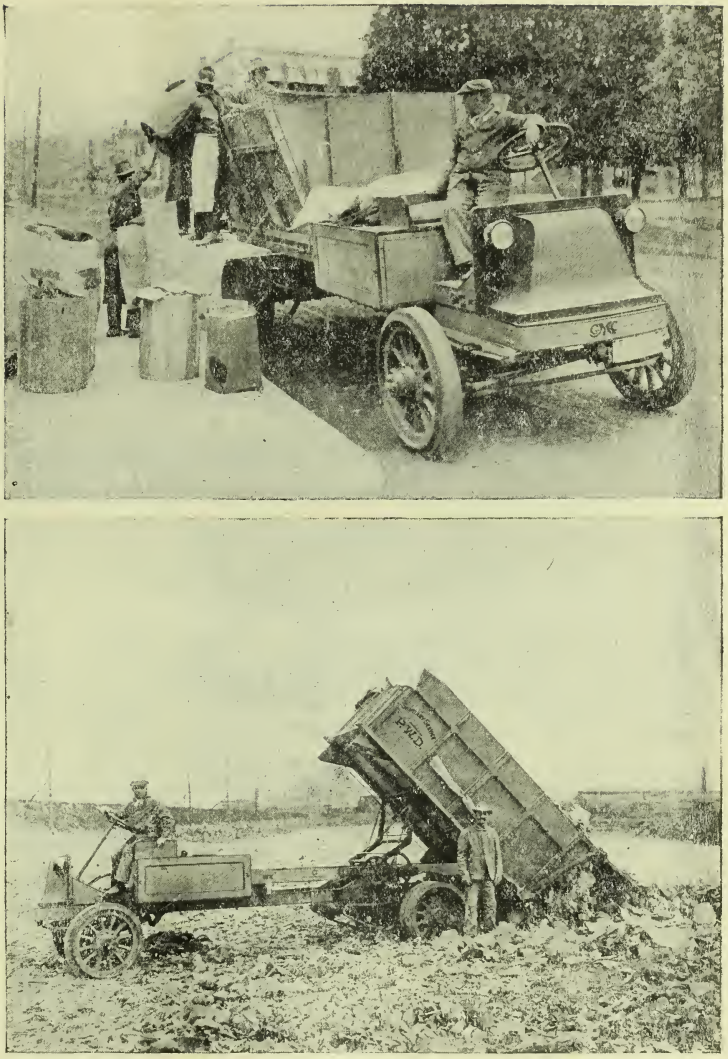


FIG. 19B.—SAME AS 19A BUT WITH BODY TIPPED.

of vehicle, is obvious. For districts some distance from the destructor these small waggons could tip into a hopper, at a district depôt, from which large capacity electric vehicles could be loaded for transit to the destructor, or the small vehicles could have removable bodies which could, by means of a crane at the district depôt, be placed direct—several of them—on a large vehicle for the same purpose.

Electric vehicles have been employed to a considerable extent on the Continent for refuse collection. The largest installation is in Paris, where the municipality possesses a fleet of 100 electric refuse collecting vehicles. Each has a capacity of a little over 15 cubic yards, which, since the local refuse averages some 3 cubic yards to the ton, makes the total load of the full vehicle not less than 5 tons. The vehicles perform their work during the night hours, each



FIGS. 20 & 21.—ELECTRIC REFUSE WAGGON USED BY THE CITY OF BOSTON U.S.A.

covering about 25 miles nightly, with an energy consumption per vehicle mile of from 1·5 to 1·7 units. This system of collection was adopted as the result of a very careful trial made by the civic authorities which showed that considerable economy would be obtainable by the use of electric vehicles.

It is satisfactory to be able to record that, as the result of a trial of electric vehicles for refuse collection, the Urban District Council of Barnes has placed an order for four vans. The following information is excerpted from an instructive report submitted to the Council by its Surveyor, Mr. G. Bruce Tomes.

It was found that one electric van per day, or six vans per week, could do the same work per week as that now done by sixteen horses and carts employed on refuse collection.

The cost of the type of electric van decided upon, complete with battery and electrically driven tipping gear, is £945. The gear takes from 10 to 15 seconds to tip, and the speed of the van on the level is about 10 miles per hour, with a total mileage capacity upon one charge of 40 to 45. The capacity of the van is $4\frac{1}{2}$ cubic yards, which compares with the $2\frac{1}{4}$ yards of the present cart.

As a result of careful tests, Mr. Tomes found that the cost of operation came out at 19s. 4d. per van per day, which figure covered interest upon cost of vehicle, as well as its share of the charging equipment, repayment of loan on both of these items, wages, electricity, tyres, maintenance of battery and chassis, insurance, lubricants, and sundries.

The comparable figure for a horse and cart is 11s. per day.

Basing his estimate upon the figures obtained by the trial of the electric vehicles, Mr. Tomes reported to his Council that the replacing of the existing horses and carts

by four electric vans would, notwithstanding a capital expenditure of £4,000 on the vans and charging plant, result in a saving of at least £400 per annum.

A similar trial made by the surveyor of the Heston and Isleworth Urban District Council resulted in the Council placing an order for an Edison electric dust van. The trial was specially interesting from the fact that experiments were made with three types of automobile (namely, electric, steam, and petrol) in order to determine the one best suited

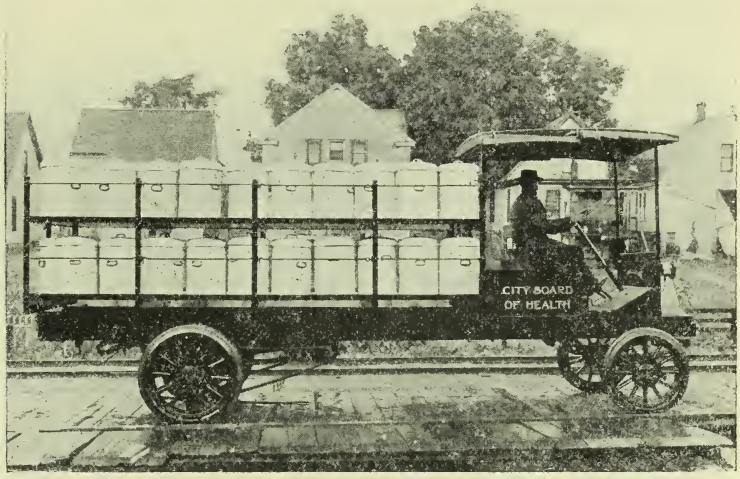


Fig. 22.—Electric Vehicle Collecting Refuse in tins in Florida.

for this work. The electric van's safe load was 2·68 tons; it had a motor tipping body, and was fitted with Edison accumulators. The Garrett steam wagon had a capacity of 3 tons, and the Thornycroft petrol wagon could carry 3·2 tons. It was found that any one of the three motor waggons could do the same work as previously done by four of the Council's horses, but in point of saving in cost over horse haulage, the electric vehicle showed £71, the steam waggon £66, and the petrol waggon only 7s. 7d. per

annum. The report of the Works Committee to the Council concludes by stating : " After careful consideration of the whole matter, the Committee have come to the conclusion that an electrically propelled vehicle would be the best and most suitable for the purposes of house refuse collection." It is interesting to note that the purchase costs of the three types of vehicles were : electric, £840 ; steam, £617, and petrol, £815 ; the estimated annual costs of working, including capital charges, being given as £333, £338, and £404 respectively. While the results in working cost for the steam waggon are a near approach to those of the electric, the Surveyor notes that the " driver of the electric vehicle does not need any mechanical knowledge, an ordinary intelligent carter being quite able to perform the duties of driver " ; while, in regard to the steam waggon, he remarks : " As is well known, a good driver is not always obtainable, *and can only be discovered by the experience gained by the cost of repairs.*"

In December of last year some interesting trials were made of the use of electric vehicles for the collection of house refuse in Birmingham. The trials are dealt with in an excellent report presented to his Committee by Mr. Jackson, the Superintendent of the Refuse Disposal Department, wherein he sums up the results in the following paragraph :

" The three tests confirmed my opinion that electric vehicles have established themselves sufficiently to justify municipalities giving their support, perhaps, at present, in a somewhat limited degree, to their development."

As a result the Birmingham Corporation have placed an order for two " Orwell " electric refuse collection vans.

Dover is another place where electric vehicles are about to be used for the collection of house refuse, the Corporation having, as the result of a trial of an Edison vehicle of two

tons capacity, decided to order six such vehicles. Each will take the place of three carts and sixteen horses. A considerable annual saving is anticipated by the change in system.

Ambulance Work.

By reason of its smooth and silent running, the uniform and jerkless acceleration, the electric is an ideal vehicle for ambulance work in our towns and cities. It has for some time been employed for this purpose by the City of London Corporation, by the Port of London Authority, and the Metropolitan Asylums Board. While the advantages just now mentioned are all important ones for this sort of work, the feature of economy should not be forgotten; while the promptitude with which calls may be answered is just as valuable an attribute as in the case of Fire Brigade Service. The simplicity of operation also enables several ordinary attendants to be trained to drive, so that a call may never find the van in want of a driver.

In regard to the City Police Ambulances, Captain Sir J. W. Nott-Bower, the Commissioner of Police, informs the Committee as follows:

"The Electric Motor Ambulance Service was commenced in May, 1907, with one electric ambulance. In May, 1909, a second ambulance was obtained, and both have since proved very satisfactory indeed for removing cases of accident or illness in the streets to hospitals.

"The initial cost of the ambulances, with surgical fittings, was, approximately, £569 and £552 respectively, and the total cost of the service is, approximately, £2,000 per annum.

"The cost of working is about 5·1d. per car mile, including expenses such as tyres, necessary repairs to cars, charging of batteries, etc., but excluding wages and rent. Tyre costs account for about 2½d. in the cost mentioned per mile.

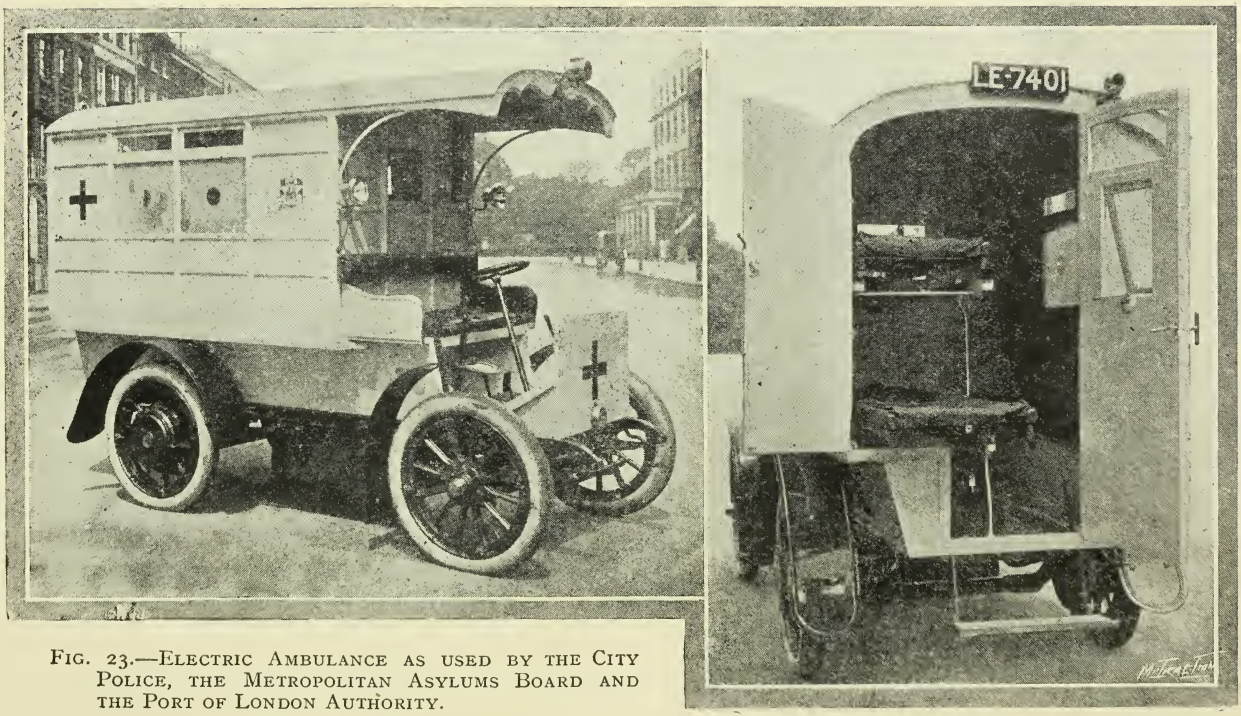


FIG. 23.—ELECTRIC AMBULANCE AS USED BY THE CITY POLICE, THE METROPOLITAN ASYLUMS BOARD AND THE PORT OF LONDON AUTHORITY.

" Another ambulance is now being obtained from the Cedes Electric Traction Co., Ltd., and will be taken into use shortly."

The Secretary of the Port of London Authority states that : " The Authority possesses four Electric Motor Ambulances, and these have been in use since September, 1912. They have been found quite suitable for the conveyance of injured persons to hospital with promptitude and comfort."

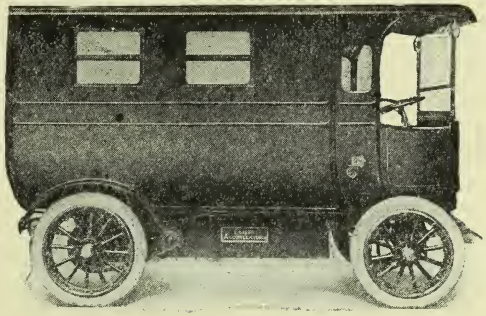


Fig. 24.—Another Type of Modern Electric Ambulance.

Electric ambulances are also in use in the United States. The New York Hospital, for example, has seven such vehicles. These vehicles sometimes make long journeys, it being recorded that one of them made a trip of fifty miles there and back to an hospital beyond the city limits on a stormy day, with mud, in some places, nearly up to the hubs, and it is added that only an hour's boosting charge was necessary in order to get the car home. The superintendent of one of the branches of the hospital where they keep two horse-drawn and one electric ambulance, thus reports as to experience with this type of vehicle : " We find the electric vehicle much more satisfactory than the horse-drawn ones, especially during the hot weather. During one hot day about eighty calls were answered, and the electric ambulance

responded to those with the longest radius, answering thirty calls in twenty-four hours."

Fire Brigade Work.

Electric battery vehicles have been in use to a considerable extent for Fire Brigade work. Notable examples of their use are to be found in London and Liverpool; while, up to the outbreak of war, they were known to be employed in several Continental cities, one having no less than 24 in use. Several towns and cities in the United States employ electrically-propelled fire engines and escapes, and there can be but little doubt that electric battery traction offers special advantages for fire brigade work, which may be summarised as follows :

Ease of Operation and Promptness of Action.—Unlike the petrol driven type, there is no preliminary starting of the engine before the vehicle itself can be got on to the move. All that is necessary with the electrically driven type is for the driver to get on the seat, throw off his brake, move the controller, and the vehicle is under way. That this feature secures a promptness in answering calls is fully confirmed by the experience of the London Fire Brigade, which possesses a total of 15 electrically propelled vehicles, the oldest having been put into commission in 1911.

At a discussion upon electric vehicles at the Institution of Electrical Engineers on March 19th, 1914, Lieutenant-Commander Sladen, R.N., Chief Officer of the London Fire Brigade, referring to the feature mentioned above, said :

"Among the advantages of electric vehicles for fire brigade work, we find that they require repairing less frequently, and that the rapidity of turn-out is absolutely

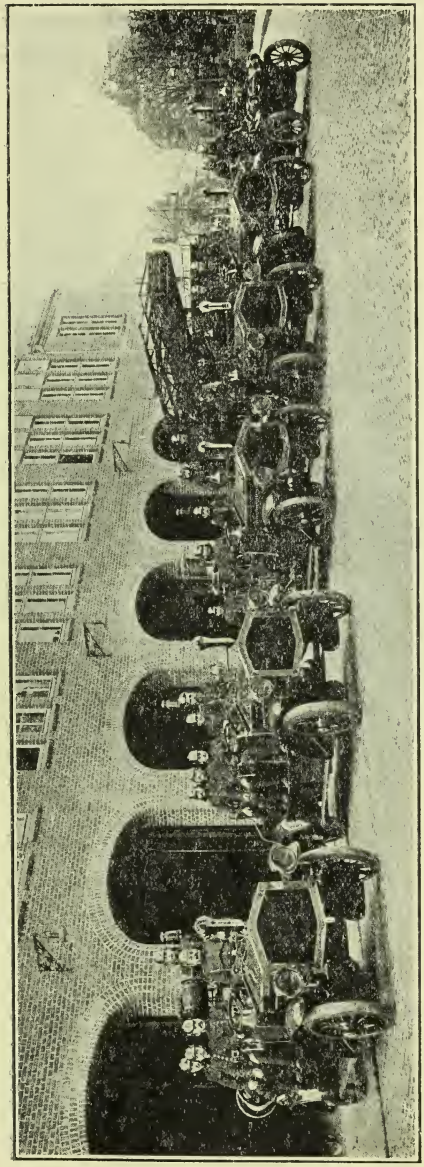


FIG. 25.—THE FIVE ELECTRIC MACHINES BELONGING TO A CONTINENTAL FIRE BRIGADE.

unequalled by any other form of traction ; it is not uncommon at an electric-motor fire station under ordinary service conditions, for a turn out to be effected in 7 or 8 seconds, whereas with other forms of motors a good turnout is perhaps 15 seconds. That is a very good point with us, especially for the life-saving appliances . . . the maximum speed is at once obtained, whereas with other forms of traction, namely, steam and petrol, a little time has to elapse before things become quite normal."

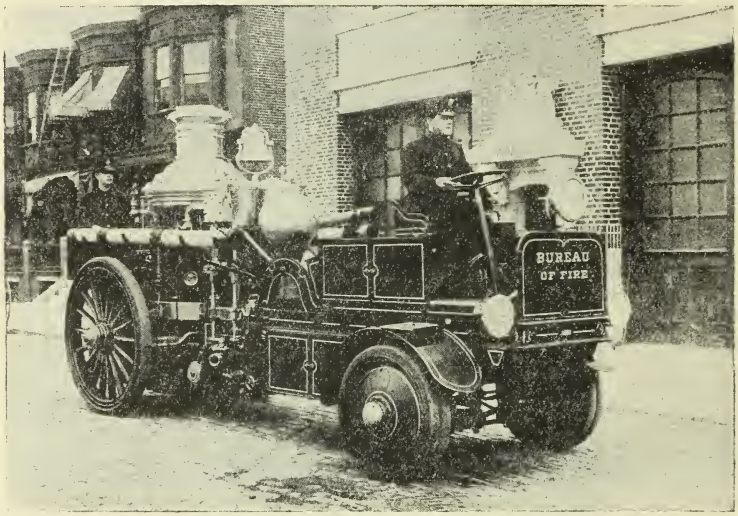


Fig. 26.—An American Horse Drawn Steam Fire Engine Converted to Electric Traction.

The Liverpool Brigade has had 4 electric vehicles in use since 1907—a period of some eight years. Three of them weigh about 6 tons, while the fourth scales $2\frac{1}{2}$ tons ; all four have a speed of 20 miles per hour on the level, and a mileage capacity on one charge of 30. Mr. Alex. W. Weir, the Chief Superintendent of the Brigade, writes in regard to these vehicles : " They have given every satisfaction, and are inexpensive to run, the cost working out at $2\frac{1}{2}$d. per mile.

The main features which commend this class of machine for Fire Brigade work are the practically instantaneous starting ; rareness of failure on the road ; the ease with which defects may be remedied in consequence of the fewness of the working parts ; the ease with which the vehicle may be driven, and the short time in which a man can be taught to drive."

Reliability.—The mechanism being so simple and the construction so strong, there is much less to get out of order

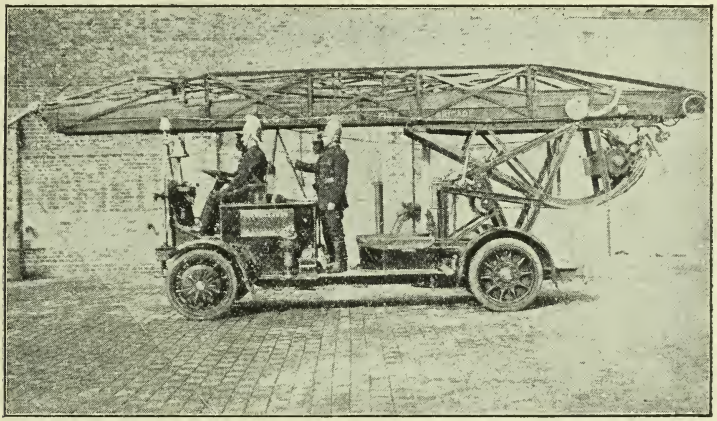


Fig. 27.—Electric Turntable Ladder Vehicle. London Brigade.

than in any other mechanical system of traction ; in fact, the day by day reliability of the electric vehicle is perhaps as much commented on as a praiseworthy feature by those who have had experience of their use, as any other point of merit which they possess. It is probably in North America, where climatic conditions are often severe, and road surfaces, even in cities, a by-word for badness, that the electric has had the best opportunity of demonstrating its capability of giving reliable service under the most trying conditions.

The Chief Engineer of the Philadelphia Fire Brigade, which possesses some electrically-driven engines, which are engines converted from horse haulage, thus deals with the reliability feature :

" During the winter, and at times when the snow was unusually heavy, and particularly during the time when traffic between the cities of New York and Philadelphia on all the railroads was held up, this apparatus performed its

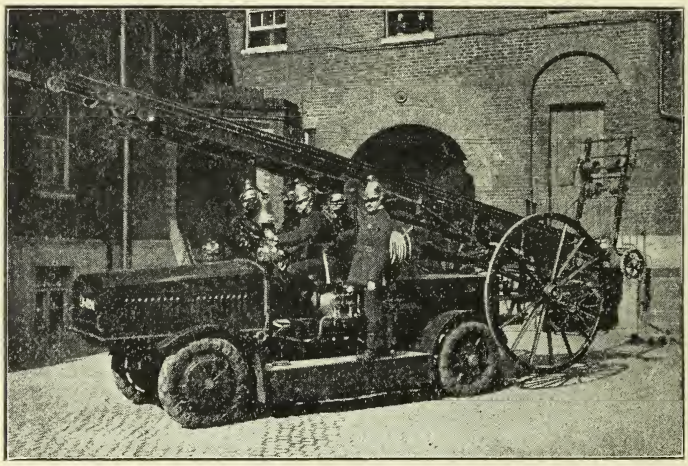


Fig. 28.—Electric First-aid Waggon. London Brigade.

duty without fail, and in one instance it was taken to a fire hydrant, where it was impossible to get with a lighter steamer with horses."

Referring to a couple of electric hose wagons which they possess, he says : " They were run about the city during last winter's heaviest snow-storms, and fully demonstrated their ability to do all that is claimed for them, *i.e.*, not to be stalled in 12 inches of snow."

He later goes on to say: "In the heaviest snow-storm of last winter (1913–14), Sunday, February 15th, we had 3 police patrol petrol cars that had to be abandoned in the streets on that night. They were towed to their respective stations by electric vehicles the next morning, after the failure of two heavy petrol vehicles to move them."

At Baltimore, the Chief of the Fire Brigade affirms that their No. 32 steam fire engine, fitted for electric traction—the only one so far converted—"is the most reliable and economical apparatus in the whole department, and is always to be depended upon."

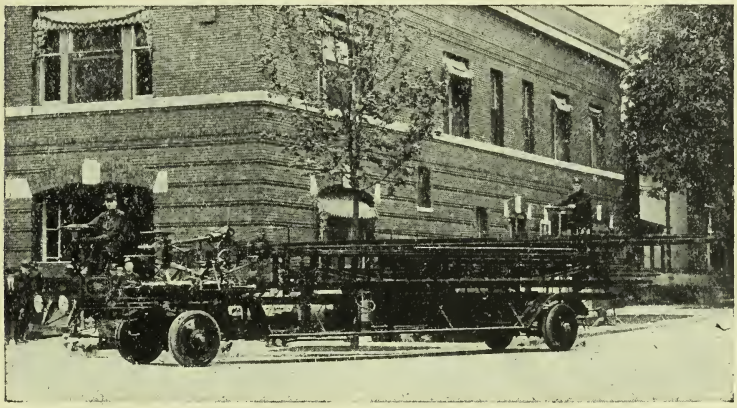


FIG. 29.—ELECTRIC FIRE ESCAPE VEHICLE, WITH STEERING AT EACH END, IN USE IN AN AMERICAN CITY.

Speaking upon this point and others, Lieutenant-Commander Sladen at the previously-referred-to discussion in London last year, said: "In conclusion, I should like to say that after four years' experience I agree with Mr. Ayton as to the advantages of the electric over other power-driven vehicles in regard to its simplicity of construction, its low cost of maintenance, its ease of driving, and its general reliability."

In regard to economy in the cost of operation, the claims of the electric on this score are fully borne out when applied to this special sort of service.

Lieutenant-Commander Sladen, speaking upon this point, stated that, in the London Brigade, the electrically propelled appliances cost, on the average, about 1s. per mile to maintain, this figure not including drivers' wages, capital charges or depreciation, whereas the similar figure for the brigade's petrol vehicles is 1s. 3d. He also went on to say: "When one takes into account the first cost and the depreciation,

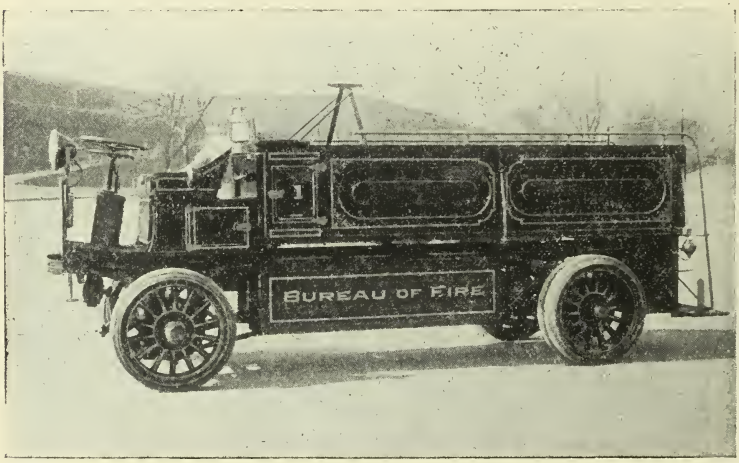


Fig. 30.—An Electric Hose Waggon belonging to an American Brigade.

the cost of maintenance of an electric fire-escape and of a petrol fire-escape are about the same, namely, about £150 a year, allowing for interest and depreciation. The annual cost of repairs for an electric escape van that runs about 800 miles per annum is £40, that is allowing for renewals of batteries and so forth." Viewed from the standpoint of the ordinary user of commercial motor vehicles, the costs per mile given above would be considered very

high indeed, but it must be remembered that the total annual mileage run by each vehicle, as already noted, is comparatively small, although the vehicle has to be kept in readiness to go out at any moment.

Further information supplied to the Committee in May of this year shows that the cost of repairs to accumulators for the previous twelve months worked out at an average price of £22 per vehicle, including a complete renewal of one battery and extensive replacements to three others.

As to speed, ample can be obtained; vehicles for this purpose have been built to run up to 30 miles per hour,

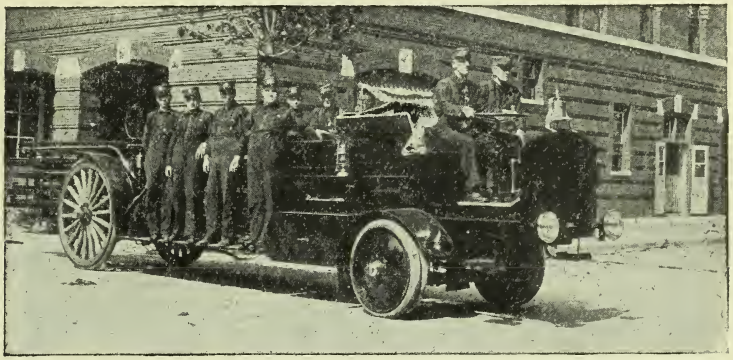


Fig. 31.—An American Electric Hook-ladder Waggon.

and, as a set-off against this feature have, of course, a correspondingly smaller radius of action on one charge, usually from 30 to 35 miles. The vehicles of the London Brigade can run up to 27 miles per hour on the level, while up a gradient of 1 in 19 the speed is 15 miles per hour.

It may be added that other advantages connected with the employment of electrics for fire apparatus include less room taken up in the station, greater cleanliness and greatly reduced risk of fire. There is also the point that any ordinary fireman can be taught to drive. To quote

again the Philadelphia Fire Brigade Engineer: "The drivers in charge of this apparatus never had any previous experience with electricity or of operating automobiles of any kind. They were instructed by the demonstrator, who came with the tractor, and since that time have practically handled the apparatus on their own responsibility."

No difficulty has been experienced in converting horse-drawn steam fire engines and other fire-fighting apparatus, the application of the front wheel drive to which the electric motor so readily lends itself, making the problem quite an easy one. This method of driving is also claimed to have the further advantage of avoiding the risk of skidding to a considerable extent.

The General Work of Upkeep and Cleansing of Streets and Roadways.

If the dumping ground for the disposal of road sweepings is some distance from the centre of the town, much time

Fig. 32.—Ipswich Corporation's 3-ton Tip Waggon at work on Making a New Road.

is wasted upon the " to and fro " journeys with the ordinary cart and horse, so that, in many cases, there would appear to be good reason for the employment of self-propelled vehicles of large capacity for this class of work. Since this service entails frequent starting and stopping, the conditions are more or less similar to those appertaining to the collection of house refuse, and the same arguments in favour of electric vehicles apply.

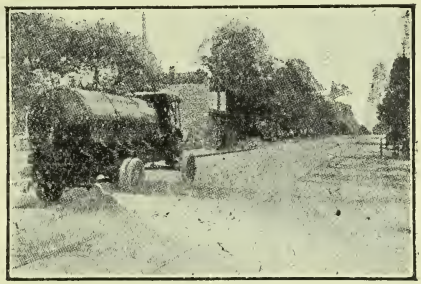


Fig. 33.—An Electric Street Watering Waggon at work.

The electric vehicle is in use on the Continent and in the United States in connection with street cleaning and brushing machines and for watering, one important Continental city having about 30 in use. In the city referred to, each electric watering van waters about 49,000 square yards of road surface per day of eight hours, as against 30,000 yards, the best average of a horse-drawn van. The saving stated to result from employing " electrics " in place of horse-drawn vans for this purpose by the municipality mentioned is about £80 per electric van per year. The electric vehicle is also employed for carrying materials used in the making and repair of roadways, and a 3-ton wagon with tipping body has just been put into service for this purpose by the Corporation of Ipswich. In reality, this wagon will be a " double-purpose machine," since the tipping body is removable, and can give place to a water-tank (which is now being constructed) to enable the vehicle

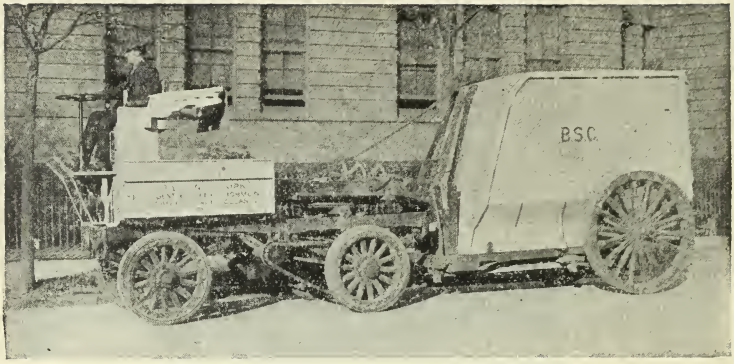


Fig. 34.—Electric Tractor drawing Tipping Van for Street Sweepings—City of New York.

Fig. 35.—Electric Street Watering Waggon—City of Galveston, U.S.A.

to be used for street watering. As the vehicle has only just been put to work, no figures as to cost of operation are yet available, but it may be stated that the energy consumption is on the average under 0·75 unit per mile. This means that at 1d. per unit, the maximum power cost is under ¾d. per mile run. It may be remarked that Ipswich is fairly hilly, and that a vehicle in such service as that mentioned has often to travel over roads in process of making where the energy consumption must necessarily be above the normal.

It has been suggested that an electrically-driven road roller would be an improvement upon the noisy steam roller

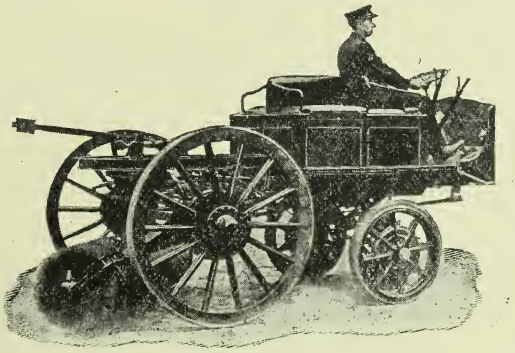


Fig. 36.—Electric Street Sweeping Machine in use by a Continental Municipality.

generally in use. Although, as far as the Committee's knowledge goes, no electrically propelled rollers have yet been introduced, there appear to be obvious advantages in that method of working and no difficulties in applying it. As weight is an essential requirement, a battery of as large a capacity as necessary could be fitted.

The Tramways Department.

It is satisfactory to be able to chronicle that there are now three municipal tramway undertakings making use of

the electric battery bus as an adjunct to their tramway services, *i.e.*, Southend-on-Sea, South Shields and York. In all three instances, it is understood that the vehicles are giving satisfaction.

Apart from the features of economy, silent running, general cleanliness and simplicity, a strong argument for the adoption of electric vehicles, as against petrol or steam driven ones, by a tramways department lies in the fact that their use entails no augmentation of the repair staff by specially experienced men, because the equipment, except the battery, being similar to that upon a tramcar, the ordinary repair staff can quite easily do all repairs needed.

The South Shields Corporation buses have accommodation for 22 passengers, the speed being 12 miles per hour on the level and about 6 miles per hour on gradients of between 1 in 8 and 1 in 10. The energy consumption per mile varies with the condition of the roads, being, under the best conditions about 1·3 units, while the figure runs up to about 2 units per mile when the roads are deep in thick sticky mud. On a fine day, each bus will run, if necessary, 50 miles on one charge. A charging station is placed at one terminus, enabling each bus to be given a boosting charge several times a day which enables a fast service to be

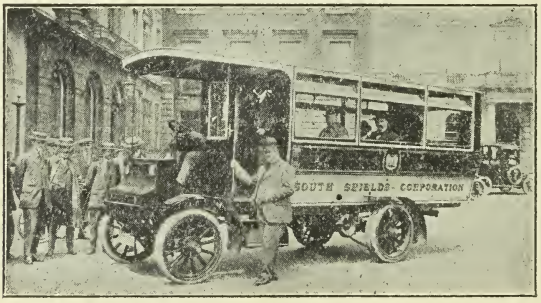


Fig. 37.—S. Shields Corporation Electric Bus.

obtained during the evening without the necessity of charging during the station "peak-load" hours. Up to date, the maintenance cost has been practically nil, and the reliability of the vehicles receives cogent attestation in the statement of the Tramways Manager—"One does not have to worry about them any more than one would about an ordinary tramcar."

FIG. 38.—S. SHIELDS BUS RECEIVING A FEW MINUTES BOOSTING CHARGE WHILE WAITING AT TERMINUS.

"The running costs for the eight months ending March 31st are 5·71d. per mile. This includes everything except interest and sinking fund on the capital expenditure. The only expenditure on repairs during this period has been incurred in connection with the chassis, and has been due to new chains, one or two controller fingers, and the renewal

of brake liners. Nothing has been done to the battery except the addition of distilled water once or twice a week and the cleaning of potash deposit from the terminals every month or so."

The bus which the Southend Corporation Tramways Department has had in use since the 26th June, 1914, is similar to those employed at West Hartlepool. The experience at Southend, however, is perhaps a little more valuable for the reason that other buses of the petrol and petrol-electric type, and of the most modern make, have also been in use alongside the electric bus. In a report presented to his Committee at the end of 1914, Mr. Birkett, the Engineer and Manager of the combined Electric Supply and Tramways undertakings, dealing with the running of all three types, says :

> " The electric bus is the most reliable and free from breakdowns. This is no doubt owing to the simplicity of the mechanism."

After going on to detail the troubles which have been incidental to the operation of the other two types, he adds :

> " The electric bus is so free from moving parts, there being only the motor with chain drive and differential, that stoppages due to breakdown of parts are almost negligible. It will be apparent that fewer spare buses of the electric type will be needed in a large fleet as compared with petrol buses. . . . Providing all necessary plant for re-tyring wheels is available, there will be no reason for possessing a stand-by electric bus with a fleet of six buses. . . . It follows that the staff at the garage would be affected in favour of the Edison bus."

As to cost of operation, after eliminating from the cost ascertained up to date certain items in connection with each type of bus which are incidental to the inception of a bus service, Mr. Birkett gives the actual average cost per bus mile (including capital charges) for each type as follows :

Petrol	8.56d.
Petrol-electric	8.31d.
Electric	7.52d.

Mr. Birkett further points out that, in his opinion, the results would be still further in favour of the electric battery bus if a fleet consisted entirely of the latter.

The consumption of energy on the hilly route is at the rate of 1.55 units per mile, while on a route which is more or less level, the figure comes down to 1.1. The bus receives a short boost while waiting at one terminus, the boosting current being about 300 amperes. The average speed, in-

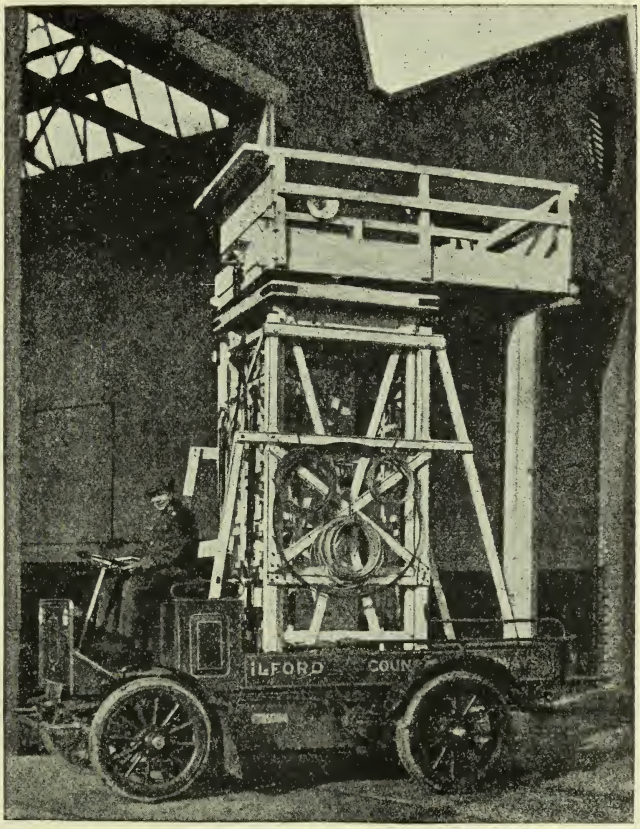


Fig. 39.—Ilford Tramways' Electric Tower Waggon.

cluding stops, is about nine miles per hour. Up to date there have been no repairs needed to the electric vehicle.

Battery buses are on order for the West Bromwich Corporation and for a company at Loughborough.

The Ilford Council Tramways Departments employ an electric tower waggon which has now been in service for over twelve months. The special advantages claimed for the electric vehicle for this work are :

(1) Can be started away without loss of time.
(2) So simple that any workman can easily drive it, in consequence of which several men may be provided with licences insuring that whenever the call may come, a driver shall always be available.
(3) More easily manœuvred against poles or under insulators and wires than a petrol or horse waggon.
(4) Hand-lamps on flexibles, for night repair work, may be operated from the battery.
(5) Reduced risk of fire when garaged at the tramways depot.
(6) Low cost for operation and upkeep.

Although the Ilford waggon weighs some 3-tons, the energy consumption is only a little over a unit per mile. With the exception of the cost of a little distilled water for the battery, no expenditure has been necessary for maintenance during the time the vehicle has been in commission, and there is stated to be no sign of wear upon the tyres.

Similar vehicles are in use by, or on order for, the Tramways Departments at Derby and Belfast.

Other Uses in Municipal Services.

There are still many districts where cesspool emptying has to be done, and, where the health and comfort of the residents is studied, the vacuum tank system has taken the place of the old and crude methods. The vacuum pump is generally driven by a petrol engine in the most modern plant, but surely the aim, in constructing apparatus of this kind, which is generally put to work during midnight hours, should be to produce something which is silent in operation—and the little petrol engines employed certainly lack this feature in no small degree. It is, however, possible to

construct an electrically propelled vacuum tank waggon—the usual capacity required is about 350 gallons—fitted with an electrically driven air pump. As such a pump will only need some 2 horse-power to drive it, the ordinary size of battery such as fitted to a 3-ton waggon, would easily supply the energy required while the waggon is standing. The advantages would be that ordinary labourers could work the plant, the cost of working and up-keep would be small, and the plant would operate with absence of noise.

The expenses of conveying the Municipal Officials about, on their business visits and rounds, aggregate into a fairly large annual sum in any town of size, and this is especially the case where hired vehicles are concerned. It would undoubtedly pay any large municipality to invest in a few electric cars for such service, which could be garaged with the Electric Supply or Tramways Departments. The simplicity of control is such that chauffeurs would hardly seem necessary. The figures already quoted in this report indicate how low is the running cost of the passenger "electric," and this feature as well as the fact that the vehicle is free from all the starting difficulties, the vibration and the fire risk of the petrol type should act as a strong incentive towards its adoption for this particular service.

The Committee are much indebted to the various firms who have kindly provided blocks or photos for illustrating this report, notably:

Messrs. Edison Accumulators (Figs. 1, 11, 18, 19A, 19B and 24).
The General Motors Co. of America (Figs. 2, 3, 20, 21, 22 and 35).
The Commercial Truck Co. of America (Figs. 15 and 16).
The Couple-Gear Freight Wheel Co. of America (Figs. 26, 29 and 31).
The Electrical Times, Ltd. (Figs. 27 and 28; both are Cedes vehicles).
The Tramway and Railway World (Fig. 39).
The Cedes Electric Traction Co., Ltd. (Fig. 23).
The Baker Electric Co., U.S.A. (Fig. 12).

ELECTRIC VEHICLE DISCUSSION.

Mr. F. Ayton, Member of Council (Chief Electrical Engineer Ipswich) : In introducing the report expressed his indebtedness to many members of the Association and many persons outside the Association, for the extremely valuable help and information they had given him. The use of the electric vehicle was suggested and advised, not only because it would bring in additional revenue to the electric supply undertakings—that was a point of secondary importance—but because it had inherent advantages of its own of no mean value. The present was a very opportune moment for putting forward the claims of the electric vehicle. It was true that at present they were living amidst the clamour and turmoil of a terrible world-wide war, but none the less it was their duty to utilise the opportunity, because in doing so, electrical engineers would be doing, in a small way, a national service. They were freeing the demand on the petrol vehicle which was so insistently needed by the military authorities in the present circumstances, and at the same time they would be doing the users of commercial vehicles a service by bringing to their notice what they did not know before, namely, the many advantages of this method of road traction, which would bring savings to them. There was another advantage of no mean importance at the present time, namely, that when the electric vehicle was adopted there was no need to call upon the services of professional chauffeurs, a class which could command high wages, especially at the present time, and whose services were most insistently needed for the military transport services. The electric vehicle had the unique advantage that it was so simple in its mechanism and operation, that it was no exaggeration to say it was possible to teach any person of ordinary intelligence—a mere youth—to drive an electric vehicle in a couple of hours. That meant that where electric vehicles were used to replace horse haulage there was no need to get rid of the men who dealt with the horses. That was certainly a feature of value because Municipalities did not like as a rule to get rid of old and trusted employees. The electric vehicle rendered it possible to change from horse haulage to motor traction, and to utilise the same men who had been previously handling the horsed vehicle. They had got to wake up their minds to the fact that the next few years would see a transformation in their street traffic. Practically the whole of the traffic in their towns, cities and suburbs would in the course of the next few years be handled

entirely by motors. It depended very largely upon what enterprise the central station people and the vehicle manufacturers showed in pushing the claims of the electric vehicle as to what proportion of that traffic was dealt with by electric vehicles. He so visualised it in his own mind that there was no reason why, if it were gone about in the right way, they should not ensure that in a few years time the greater proportion of traffic in towns and cities, within the reasonable capabilities of the electric vehicle, should not be electric. The first step to ensure that desirable end was that the central stations themselves should lead the way. It was hopeless to assume that they were going to get this business if they did not themselves show their confidence in the advantages of electric vehicles, and that of course meant they must be users. If they could get the other Municipal departments to use electric vehicles so much the better. They then had a still stronger case to put before other business people in their different localities. In order to encourage the use of the electric vehicle, they must also provide themselves with means for charging it. A good deal had been done already in that direction. The Committee had every reason to be very satisfied with the way in which central stations on the whole had come forward and made special tariffs applicable to electric vehicles, and in many cases had arranged for charging facilities, but it was necessary to go much further. In a few years time practically all electrical supply undertakings in towns of any size must have their charging stations, so that no person who was going to buy an electric vehicle could say he could not get it charged. Unfortunately, that was the position to-day. He heard only a few days ago of a man who had bought an electric vehicle to run between two towns. He had paid a good deal of money for it, but he was now going to sell it because he could not get charging facilities in either of the two towns concerned. Unless these facilities were provided it could not be expected that much would be done in promoting the general adoption of the electric vehicle.

In conclusion Mr. Ayton said that if there was any information not contained in the paper which any member desired to have, he would be only too pleased to supply it if it were within his power.

Mr. W. W. Lackie (Past President) (Chief Electrical Engineer, Glasgow) said that the whole electrical industry in this country was indebted to Mr. Ayton for the manner in which he had taken up the question of popularising and educating them all as to the possibilities of the electrically propelled vehicle. It was directly

due to his energy and initiative that the *Electric Vehicle*, the organ of the Electric Vehicles Committee was started, and had since been so successful. Mr. Ayton had also done much valuable work as Honorary Secretary of the Electric Vehicle Committee. Municipal electrical engineers were specially indebted to Mr. Ayton for the valuable and comprehensive report which left very little room for criticism or supplementary comment. In the first half of the report practically the whole of the comparison is made between horse and self-propelled vehicles, but in the latter part the comparison is confined to the petrol vehicle versus the electric vehicle, which he thought was really the problem they had to face. A very interesting figure was given in the report by the Urban District Council Surveyor of Barnes. He said that one electric van now did the work, formerly done by sixteen horses, and this figure was further confirmed by the Dover authorities, when it was stated that one 2-ton van took the place of three carts and sixteen horses. If they took the price of a Cleansing Department horse at £50 (he supposed the present price was more likely to be £70), it meant that a car costing £800 was comparable with the first cost of horse haulage. The experience of the Heston and Isleworth District Council was convincing and helpful. The Philadelphia illustration of the reliability of the electric fire escape vehicle should be brought to the notice of the head of every fire brigade in the country. This statement was to the effect that three police petrol cars had to be abandoned in the street in a heavy snow storm and these cars were towed to the fire station by the electric van next morning. It was perfectly evident from the report that Municipal engineers have not only to be interested themselves in electric vehicles, but they must seek to interest the Medical Officer of Health, the Cleansing Superintendent, the Firemaster and the Burgh Surveyor. There was just one use to which the Glasgow Corporation had put their electric vehicle which was not mentioned by Mr. Ayton, and that was for pressure testing of plant in a sub-station before the supply was available. The Corporation had a small motor generator which could be put inside a 1-ton van and this was taken to a sub-station. The motor was connected to the battery of the vehicle and drove an alternator giving alternating high tension current at 13,000 volts for testing the 6,500 volt plant. A similar arrangement might be used for the testing of mains. For practically every purpose except touring, the electric vehicle is superior to vehicles propelled by other means. He thought, however that in putting the case for the electric vehicles, it was as well to get right up against the only real

competitor, viz., the petrol vehicle. For ordinary carting purposes the Glasgow Corporation a few years ago were charged 7s. 6d. per day for what was called a horse and cart. To-day for a similar animal and vehicle the cost was 11s. 6d. The horses supplied, however, were not the £50 or £70 kind used in the Cleansing Department of the city. With a service at 11s. 6d. per day it was costing them £160 per annum for a horse and cart, and with a 1-ton van they were easily doing what two horses and carts did for £240 per annum as against £320 for horse haulage. The Corporation now had had three years' experience with a 1-ton van and the results had been so satisfactory that three other vans were ordered some time ago and had only recently been delivered. The original 1-ton van was equipped with the smallest size of Edison battery, and it was found that with one charge it could do 35 to 40 miles. When he came to order further vans, he took the opportunity of putting in an A 6 battery into the 1-ton van and putting the A 4 battery into a new ½-ton van. The Corporation found that 35 miles a day did not meet their average requirements for a 1-ton van, and with the A 6 battery they could get 60 miles with one charge. The other two vehicles they had ordered were a 1½-ton lorry and a 3-ton lorry. Although they had not yet had any lengthened experience with the new vehicles, they promised to comply with their requirements and with the promises made with regard to them by the makers. From the electricity supply undertaking point of view, the electric vehicle is a very promising consumer. With electricity at 1d. per unit the probable revenue from electric vehicles might be taken as follows: from £20 per annum for ½-ton van to £40 per annum for a 3-ton van. The Glasgow Corporation had leased a building in a central position in the City as a garage, with a floor area of 10,000 sq. ft. Charging plant, specially suitable for charging these vehicles, was being installed and the space at their disposal permits of outside cars being taken in for charging. There was no reason why carting contractors should not come to use the electric vehicle, even for occasional work, as the varying demands and conditions of their customers would enable them to use the vehicles constantly, just as they presently do with their horse-drawn vehicles. The one drawback to the electric vehicle is its first cost. This, however, will no doubt be rectified in time, but it must be rectified if we are to get ahead with the use of the electric vehicle. Dr. Steinmetz, of the General Electric Company of America, in the course of an address before the Electric Vehicle Association of America in January, said that automobiling was at present very much

in the same condition as cycling was eighteen years ago ; its attraction was chiefly that of sport. Mr. Lackie went on to point out that the greatest present need in the industry is a light cheap electric vehicle corresponding to the Ford petrol car. He estimated that the cost of charging an average passenger light car with energy at 1d. per unit would be £12 per annum. This opened up very promising possibilities for the large number of business people who reside in suburban areas. The Electric Vehicle Committee had very properly standardized charging plugs and one or two other important details, but he thought something must be done in the way of standardizing the weights and sizes of trucks of different carrying capacities. For instance, the weight of the Glasgow Corporation's ½-ton van complete was 39½ cwts., and the 1-ton van complete weighed 40 cwts. A hopeful development was that firms who formerly confined themselves to the manufacture of petrol cars are now finding it worth their while to turn out electric cars as well. The Arrol-Johnston Company at Dumfries had, he understood, made several electric cars, and he noticed in the *Electrical World* (of New York) some time ago that a Daimler electric truck had been procured for the work of the Vienna Post Office, in connection with which it had covered 7,500 miles for the first twelve months it was in use. The General Postmaster reported that he had found the electric truck to effect a saving of some 20 per cent. in operating costs, besides its manifest advantages of safety, cleanliness, simplicity, noiselessness and absence of odour.

Mr. C. H. Wordingham (Past President) pointed out that there were certain questions which the advocates of electric vehicles would have to answer whether they were specifically put to them or not. Looking back over the history of traction generally one could not but remember the numerous attempts that had been made to run tramcars by means of batteries. The tramcar presented the nearest approach to ideal conditions for durability of the battery that could be obtained, but was it possible to point to any single instance in which battery-driven tramcars had been a success ? That was the first question that should be answered. The next that we were face to face with was that certain electric tramway companies using the ordinary trolley system had not been able to pay, but as soon as some of them had introduced petrol-driven cars of the ordinary kind they had become dividend earning. Why was it that the present advocates of electric vehicles looked forward to so much success with such vehicles running on ordinary roads, when tramcars

using batteries and running on tram lines had been such an abject failure? Mr. Ayton referred in the report to the simplicity of the car, and mentioned that he would like to take a youth and give him two hours' training and then trust his own precious life to this young "advertising nipper" as he might be called. Something more than simplicity in the car was required to make a driver. The idea of giving demonstrations of the advantages of electric supply by means of the electric vehicle was an exceedingly happy one and should give excellent results. The demonstration apparatus would have to be specially designed for the low pressure of the battery, but that was a small detail. It was also suggested that the power in the car could be used for drawing cables into pipes. His only comment on that was "Poor cables!" Another point to which he would draw attention was the necessity for really convincing demonstrations of the merits of these cars. He had tried very hard indeed to get rid of the impression made on his mind by the demonstration at the Kingston-upon-Thames Convention. He came up to London in one of the electric cars, but Kingston Hill disabused his mind of any favourable opinion he might have formed of electric cars. The car did certainly move up the hill and he did not get off. He would say no more. Nothing could be more unfortunate than to show an electric vehicle which crawled and which gave the impression of being very heavy. He presumed, however, that the report was largely directed to advocating electric vehicles for utilitarian purposes and not for pleasure cars. Might he suggest that they should try to demonstrate one of these cars in comparison with the sort of cars they desired to displace. They might, for instance, arrange for a race between an electric car and a dust cart or something of that sort; then they might be able to convince people how much better electric cars were. In conclusion he would like to refer to the standard plug. The Electric Vehicle Committee had been working in conjunction with the Engineering Standards Committee which had standardized the leading dimensions of the plug. The standard specification had not yet been issued and it might be thought that the Standards Committee had been dilatory. So far as the Standards Committee was concerned, however, everything was completed last January, but unforeseen difficulties arose in connection with preparing the gauges and getting these gauges actually made to specification. Consequently the specification had been delayed, but he was happy to say that these difficulties were now at an end and the standard specification would be formally issued very shortly.

The Chairman said Mr. Wordingham seemed to be rather depressed. He was quite sure that at the Admiralty they did not follow the precepts Mr. Wordingham had just enunciated. If the British Navy had never gone in for new things or made experiments, it would not be holding the important position it held in the world to-day. He could not help thinking there must be something in the atmosphere, or perhaps the lighting of the room which had depressed Mr. Wordingham.

Mr. R. A. Chattock (Past President) (Chief Electrical Engineer, Birmingham) said he joined the Committee with a perfectly open mind, but since his connection with the Committee he had come to the conclusion that the electric vehicle was the vehicle for the industrial side of the community, *i.e.*, for commercial use in carrying goods and heavy haulage. He did not suggest it was of use for long distances at present ; that might come later when the industry had been properly organized. It was clear, however, that the electric vehicle this year was far ahead of what it was at the Kingston demonstration two years ago. Mr. Wordingham had explained that he had travelled back to London in one of the vehicles from Kingston. He was sorry for Mr. Wordingham, but did not think he should base his conclusions on that trip. There was no doubt that in those days, and even now, many of the electric vehicles were not speedy machines, and it was unfair to judge of their performance compared with what we were used to in petrol vehicles. People did not go for pleasure runs in petrol commercial vehicles, but in a private car or taxi-cab which had a good turn of speed, and we should not judge the performance of an electric vehicle which was not supposed to go more than 12 miles an hour with a petrol vehicle which was intended for quite a different purpose. He agreed that what was wanted is a very light runabout car for carrying passengers, and the lighter the better. The Ford petrol car had shown what could be done with a very light and cheap vehicle, and if the electric vehicle makers could be induced to produce a car on these lines, *i.e.*, very light in itself and fairly cheap, it would have a very big sale in this country on the part of electrical undertakings and also in ordinary business undertakings, chiefly for running about in cities. He believed there was one car which had been recently put on the market which met these conditions. It was an American car, but most American cars were too expensive to buy for this purpose. Mr. Wordingham had criticised the possibilities of the electric vehicle taking on in this country from experience obtained with

tramways run by batteries. A tramcar was a very heavy vehicle, weighing about 3 tons in itself, and it had to run much faster than a goods trolley. It was hardly fair to assume that because a tramcar had not run satisfactorily by batteries, but did run satisfactorily from a trolley wire, therefore an electric battery was not the proper thing for an ordinary road vehicle. If they were to try and pull a tramcar with horses or with petrol they would not get any better result than if they tried to pull it with an electric battery. In America there were upwards of 70,000 battery vehicles running, some heavy and some light, and he did not see why Mr. Wordingham had put the comparison with the tramcar before the meeting, and suggested that the battery vehicle was unsatisfactory on that account. He was glad that reference had been made to the Standards Committee, and to have this opportunity of thanking them for the great assistance they had been to the Electric Vehicle Committee and for the way in which they had worked with them in standardizing the plug and receptacle for vehicles in this country. The gauges for making these plugs and receptacles had been submitted to the Electric Vehicle Committee within the last two or three days, and he was glad to say they were quite satisfactory as far as the Committee was concerned and the matter could now go forward. If the Standards Committee issued their specification in the usual form, this would be quite satisfactory to the Electric Vehicle Committee.

Mr. J. W. Beauchamp (Member of Council) (Chief Electrical Engineer, West Ham) said that in West Ham there were only four users at present of electric vehicles. They had altogether ten vehicles: two 2-ton; three 1-ton, and five ½-ton. Six out of the fleet of ten were repeat orders based on the experience of the first one in each case. Three out of the four users had had much experience of other forms of mechanical transport before taking up the "electric." He said the most direct and obvious method of "pushing" the electric vehicle was for the Supply Department to use one. In his opinion a commercial vehicle or cart was of greater direct advertising value than a Staff runabout. People might look upon a Staff runabout as a luxury into which perhaps the commercial proposition did not enter, but when they saw the ordinary cartage work of the Electricity Department being carried out on an "electric" they would conclude that it was at least as cheap as other forms of transport. Mr. Beauchamp's own experience of a 1-ton Edison in use by the Mains Department was as follows: In use 27 weeks = 148 working

days of 5½ days per week; average mileage per day, 17½; average running hours per day, 2½; average journeys per day, 10½; the area was practically a rectangle, 4 miles by 2 miles; consumption of electrical energy. D.C. input, ·6 units per mile at 1d. per unit D.C. input to battery; revenue from mixed commercial electric vehicles appears likely to be between £20 and £30 per vehicle per annum, to the Central Station. He thought it was very desirable for the moment that the efforts of all Central Station men should first be concentrated on the big users of heavy vehicles, those who now employed pair-horse vans, steam or petrol vehicles of one ton upwards for regular work within limited distance. These people were able to charge vehicles on their own premises and are very quick to notice any overall financial advantage, and they have in most cases made an accurate study of transport by other means. Business of this kind offered the fullest conditions for success, giving heavy loading, restricted radius of action, comparatively high proportion of running hours. At present there were, he said, not many different types of electric vehicle on the English market, and in pushing this business he thought for the moment it was as well to avoid confusing the prospective user by presenting to him several alternative types, as the efforts of the various makers to sell their vehicles was very apt to distract the mind of the prospect, who frequently finished up by saying that the electric vehicle was obviously in a state of development and that he had better wait a few years. The best practice appeared to be to pick any particular make in which one had confidence and push it for all it was worth to the particular prospect in view, dealing, if desirable, with the next inquiry with another type of vehicle. It is worth any amount of trouble, he said, to get the first electric vehicle in use, as the satisfaction given is so great that repeats then follow without further effort. The review of the business which has been done in this country in the past two years, should be sufficient to prevent anyone from being discouraged by the difficulties which attended the placing of the first vehicles. It was also worth while to remember, said Mr. Beauchamp, that one hundred mixed commercial electric vehicles will consume half a million units per annum, producing at 1d. per unit a revenue of over £2,000 per annum. As an off-peak load, a very large percentage of this £2,000 extra revenue would appear as profit in the accounts of the Electric Supply Department.

Mr. G. Bruce-Tomes (Surveyor to the Urban District Council of Barnes) expressed his satisfaction with the working of the

electric vehicles used in his Sanitary Department. They had saved a great deal of money, and by reason of their condition in handling, were a great advance on anything he had yet used for the collection of house refuse. The great saving was caused by the speed of the vehicle, and the difference between the time-table of collection and travelling. With horsed vehicles the travelling took about 6½ hours per day, and the collection 2½ hours per day, but with electric vehicles they were able to collect during 6½ hours a day, whilst the travelling only occupied 2½ hours per day. They were also exceedingly useful from the point of view of quietness in the streets in the early morning, as compared with the noise made by the ordinary horsed van which usually had a galvanised iron cover. On p. 92 of the Report, reference was made to the fact that one vehicle did the work of sixteen horses; that should read one vehicle per day, so that the comparison would be six vans against sixteen horses.

Mr. H. S. Ellis (Borough Electrical Engineer, South Shields), referring to the Edison omnibuses which had been put into service by the Tramways Department of the South Shields Corporation, said that these had now been running for some considerable time with success. Particulars of them were given in the Report, but it might interest the members to know that at the present time these buses were used as feeders to the ordinary tramway system. They were sent into an outlying district along roads which were at present not suitable for ordinary traction purposes, and the Tramways Committee were apparently quite satisfied that the buses had done all that was expected of them. They were charged at night-time at the car shed, where a motor generator set had been installed, and the Electrical Department charged ¾d. per unit for the current provided it was taken between 11 p.m. and 6 a.m. He did not feel the effect of this charging current upon the generating station, and even if there were twenty buses instead of two, he did not think he would feel it. This went to show that such buses were inclined to have a very beneficial effect upon the load factor of electrical undertakings. The buses, after being charged, were sent on to the roads, and at the end of the route there was a small charging station which was utilised for giving a boosting charge for the accumulators. The result was that the bus was able to remain in service the whole day long, and travelling from 70 to 80 miles per day, whereas, if there was no boosting station, the distance would not be more than 40 or 50 miles. The Electricity Department at South Shields was doing all it possibly could to push

the use of electric vehicles, and at the present time an inquiry was under consideration from a brewery for a 3-ton vehicle. He could not, however, help feeling that he was up against a tough proposition. First of all there was the question of cost. An Edison-battery vehicle of the type required for the brewery would cost £1,100. A Baker vehicle, he believed, could be obtained for about £700, whereas a petrol vehicle would cost £600. That was a disadvantage, but he hoped it would be got over. Another disadvantage was the question of speed. He had taken this up with people who had these vehicles in different parts of the country, and the general impression was that they were excellent for town use, but that they could do nothing in the way of long journeys without a greater speed range. That was for the battery people to deal with, and he did not see any particular reason why (with a vehicle designed to carry 3 tons) the capacity of the battery should not be increased to enable a higher speed to be obtained, because speed was a very important factor. They would not get a suitable return for their money unless mileage was got out of the vehicles. The advantage of the electric vehicle was that it was cheap to run, very easy to handle, and the maintenance costs as low as they could possibly be made. With regard to scavenging, for which he regarded the electric vehicle as very suitable, he was sorry to see a suggestion in the Report with regard to the collection of refuse. Mr. Ayton stated that horse vehicles might be used for collecting refuse, but probably he meant that electric vehicles were so costly that it was hardly worth while sending them down back lanes, and that horse vehicles could be used for this purpose, and the refuse transferred to the electric vehicle, which would take it to the tip. Personally, however, he would rather use an electric vehicle for that purpose than horses. It was just the very field for it. He sincerely hoped that the Electric Vehicle Committee would do all that was possible to influence makers to bring down the price, and if possible to increase the speeds.

Mr. J. W. Hame (Chief Electrical Engineer and Tramway Manager, York) said the Corporation had four electric omnibuses fitted with Edison accumulators, the first of which was put into service during February. The buses had run up to date 13,600 miles, and the current consumption, including the consumption for over-charging and losses in the boosters, was 1·1 unit per mile. If the Corporation had purchased petrol buses, and assuming the usual basis of about 7 miles to the gallon of petrol, it would require 180 gallons of petrol per week on the same

service, which at present amounted to 1,280 miles a week. That would give a bill of about £509 a year for petrol. Using electricity at 1¼d. per unit, and taking the consumption as at York, would cost £365 per annum. Thus there was a considerable saving and at the same time a customer for the Electricity Department which was bringing in £1 per day. If they took the amount of coal necessary it would cost £64 to produce the same amount of transportation as it cost £500 in petrol, and this showed great economy upon the point of view of power consumption in the electric bus compared with the petrol bus. The buses themselves were popular, and very little criticism was heard in connection with them. There had been extremely little trouble, and, so far as electrical equipment was concerned, no trouble whatever. On the whole York was well satisfied with its electric buses, and where the roads were anything like level such a service could be used very satisfactorily. At the present time there were no other electrical vehicles of any kind in York, but several people, including the North Eastern Railway Company, had the matter under consideration, and he hoped soon to have some vehicles in York for ordinary commercial purposes.

Mr. C. H. Cooper, M.Inst.C.E. (Borough Engineer, Wimbledon) stated that the vehicles used by Municipal Authorities were, as a rule, of antiquated types, even for horse haulage. Municipal bodies had not the advantage which tradesmen had in seeing annual exhibitions of various types of vehicles required, there was therefore not the same inducement to improve municipal vehicles, as was afforded to tradesmen.

Electric haulage had a unique opening, so far as municipal vehicles were concerned, especially now that the cost of horse haulage had increased. To succeed, however, the vehicles to which electric haulage should be applied must be designed so that no undue expenditure of manual labour is incurred. At present much of the time of those engaged in road repairs is wasted in the men walking from place to place ; if the vehicles engaged had the means of conveying these men, the work they were engaged on could be much more economically carried out.

In order to load the dust van tried at Barnes, the dustman had to carry the contents of the bin up a ladder ; this necessitated enormous expenditure of manual labour, which was quite unnecessary and involved great delay.

He had paid considerable attention to the vehicles recommended by the various firms who are exploiting electric haulage in this country, but, with the exception of the vans used in New

York and Paris, he had seen no designs that facilitate loading and unloading. In both these cities the vehicles have exceptionally low bodies, so as to facilitate the handling of the material carried.

The suction from rubber-tyred wheels rapidly disintegrates road surfaces, wherever water can lodge, and unless the depressions or holes are filled up as they occur, the labour involved in repair is much increased. What is required to keep roads in good order is a vehicle carrying the necessary hot tar and grit to fill in the depressions or holes formed. Such a vehicle should carry the men required, not exceeding four in number. The vehicle could travel from place to place, and so effect considerable economy.

Early last year, when Mr. H. Tomlinson-Lee, Borough Electrical Engineer, Wimbledon, mentioned the subject of electric haulage to him, he stated that the road roller was the vehicle which appeared best suited for such haulage, especially as it was almost impossible to get steam-driven rollers with a centre of gravity sufficiently low to insure stability.

Although he has been in communication with various makers since the date mentioned, he has not come across anyone who will take the matter up.

The application of electricity to propulsion seems to get rid of a feature connected with steam propulsion which is detrimental to the road surface, namely, a thrust from the engine, which is by many considered to give rise to corrugations which tend to reduce the life of the road.

There seems, at present, no chance of obtaining vehicles suitable for Municipal work unless one is to have such vehicles built apart from the manufacturers' workshops.

Alderman Lloyd (Bristol) said he was keenly interested in this matter, not only as Deputy-Chairman of the Electricity Committee of Bristol, but also as Chairman of the Sanitary Committee. They had two hundred horses of their own, and also used others supplied by contractors to the extent of one hundred. He was very grateful to the Electric Vehicle Committee for their efforts in bringing the question of electrical propulsion in civic work to the front. It was clear that in the near future all the municipal work of cities would have to be carried out by motor traction, and it was very necessary that we should, having made a start, not adopt the wrong system and then have to change over to the right system later on. He was quite satisfied that the future form of traction for municipal work was the electric

vehicle, and it appeared to him that Mr. Wordingham had been trying to put a wet blanket on the whole thing. It recalled to his mind the predictions that were made by a leading scientist in connection with the first steamship which ever crossed the Atlantic and which started from Bristol. Dr. Lardner, who had come down to give a lecture in which he mentioned the resistance of water, the resistance of air, etc., laid it down as an axiom that it would be impossible to drive a steamship across the Atlantic. We know what the result was to-day. He was not so sanguine as to believe that the electric vehicle of to-day was suitable for pleasure journeys, but in a town like Bristol of something like 27 square miles, there was room for an electric vehicle for gathering up the refuse and carrying it away to the tips.

Mr. H. Webber (Keighley) said he had had eight petrol motor buses for two years, and they cost 1s. 4½d. per mile on the basis of a five years repayment of the capital. It was impossible to run tyres at less than 2d. per mile per bus, and it had been found that these petrol buses were so expensive that the Keighley Corporation gave them up, and substituted trackless trolley vehicles. He had now had two years' experience of these, and had found that the cost of tyres was only a quarter of what it was with the petrol buses on exactly the same roads. He had managed to fix up a three years' contract at ½d. per bus mile for tyres instead of 2d. The current consumption on these vehicles was 0·9 unit per mile, and it was charged at 1d. per unit. The petrol buses gave 5 miles to the gallon. Mr. Hame had not mentioned whether he made his buses pay, which was rather an important point. The trolley vehicles he was running at 7d. per bus mile, against the 1s. 4½d. for petrol buses, whilst the revenue was 11½d. per bus mile.

Mr. Ayton asked whether Mr. Webber, in his over-all charges for the trolley buses, included capital charges on the cables and control wires.

Mr. Webber said he did. The system in use, he added, was the Cedes-Stoll system, which only required two wires instead of four, and the sockets were exchanged as the buses passed each other. The actual cost of the overhead equipment was £923 per mile, and the buses cost £740, and allowing repayment on a ten years' basis, for the vehicles, and twenty years for the overhead equipment, the total costs work out to 7d. per mile.

Mr. J. K. Brydges (Chief Electrical Engineer, Eastbourne) gave some particulars of the running of petrol motor buses in Eastbourne. The service had been running fourteen years, and now the fleet consists of fourteen double-deck buses. The figures in the paper appeared to refer only to single-deck buses, but he thought that a service of electric buses must be double-deckers, especially if they were to be used in towns. As to costs, the last speaker's figures for petrol buses seemed to be excessive. In the paper the average figure given for petrol buses run by Mr. Birkett at Southend, was 8·56d. per bus mile. This is for single-deckers, and will probably increase as the buses wear out. The cost of the Eastbourne buses last year, including capital charges, worked out at exactly 11d. per bus mile—very different to the Keighley figure of 1s. 4d. The year before last the figure was 11·8d., so that there had been a slight improvement. These figures were inclusive of capital charges, running repairs, maintenance, tyres, management and general expenses. With regard to tyres the Keighley figure of 2d. per mile was also excessive. The Eastbourne tyre costs worked out to 1·37d. per bus mile. He had not yet seen a double-deck electric omnibus, but last year in Birmingham the members would remember the petrol electric vehicles which they used, and which were very slow on hills and would not do for Eastbourne. Perhaps, however, they had improved during the last twelve months. He believed the Eastbourne buses ran from 90 to 100 miles per day, and if they were electric they would be charged at the power station, which was adjacent to the bus depot, and there would be the expense of boosting station elsewhere in another part of the town. The vehicles ran up to 15 miles an hour, but he could not say the average speed. An interesting point was raised in the paper as to the use of electric vehicles for carrying coal where a generating station was not provided with means for direct delivery. It was suggested that an electric wagon of "suitable capacity" might be used for this purpose, but what was an electric wagon of "suitable capacity"? In his opinion it should carry not less than 4½ tons, at least, and 5 tons for preference, especially if the distance was great or exceeded 1½ miles. At Eastbourne they had to carry all the coal from the railway station to the works by road. Formerly it was done by a contractor at the rate of 1s. 6d. per ton, based on a charge of 11s. 6d. per day for the horse, cart and man. The Department had now had a steam wagon doing the work for just over twelve months at a cost of 11·1d. per ton. He had gone into the question of an electric coal wagon about eighteen months ago, but the price was excessive for one

thing, about £1,100, and the amount it could carry was limited, whereas the steam wagon cost £550 and carried 4½ tons. The total distance covered by the wagon was 2½ miles from the station to the works and back again empty. Three men were employed, namely, a driver, steersman, and loader, and these between them cleared six 4½ tons loads per day. If electric vehicle manufacturers could put up an electric wagon at a reasonable price, to do as well as that, he would be very pleased to consider the proposition when his steam wagon wore out, or he might dispose of his steam wagon, as an electric vehicle would be a most excellent advertisement for the Electricity Department. In Eastbourne there was a lot of heavy traffic, such as furniture removal vans and brewers' drays, now operated by steam power, and it would be a good thing for the town and for the electrical undertaking if electric vehicles be employed.

Alderman Meyer (York), speaking with regard to the subject of buses, said it did not help very much to say what petrol buses or electric buses could run at. It was necessary to know the actual speed which could be got out of the buses in commercial working. In York, with narrow streets moderately crowded, both trams and electric buses were being run, and both were timed to do about the same amount of running per hour. The buses seemed to run slowly, particularly on a gradient, but they run as fast as is reasonably safe, and in practice the journey from point to point is accomplished at about the same speed as the tram. Something over 7 miles an hour was the average, including stoppages, and he should doubt whether the average speed of petrol buses in similar circumstances would be very much greater. Speed is a big factor in determining the economy of use in electric buses, because interest and sinking fund are a heavy item per car mile, and the cost per car mile depends upon the number of miles which can be obtained in the running of the buses. The figure of 11d., given for Eastbourne, might be very satisfactory from Eastbourne's point of view, but he felt satisfied that at York, with single-deck buses, they were running at considerably less cost than that, although it was early to talk about actual figures yet. He was of the opinion that it was probably 2d. less than the Eastbourne figure; he would be disappointed if it were not. The question of speed which troubled a good many people was not, in his opinion, looked upon in the way it should be looked upon. The thing to look to was the distance that could be got out of a bus, including stoppages, in

the course of ordinary working, and he would like to see some figures about that.

Mr. J. Christie (Past President) (Chief Electrical Engineer, Brighton), expressed the opinion that if progress was to be made with electric vehicles, it was essential that station engineers should practice what they preached, and, as far as possible, use electrically-driven vehicles in their own service. As a start, he felt that he could not get his Committee to spend £600 to purchase a handsome car *de luxe* like that at Croydon, but he was able to persuade his Committee to allow him to spend about £200 to purchase piecemeal the vehicle which was depicted in Fig. 9 of the report. That had been in use for eight or nine months and it had been most valuable to him in running round the town in connection with his work. He ran about 20 miles a day on it, and it had created a very favourable impression in the town and aroused a great deal of interest amongst the tradesmen, and before long he hoped to have a number of electric cars in the service of tradesmen. There had been a fleet of sixteen electric omnibuses working in Brighton for eight years, and the Electricity Department sold 800,000 units per annum for charging the Tudor batteries on these buses. They were old-fashioned buses, but worked well in spite of their age, and give great satisfaction still. The biggest field for development, however, was in the works departments of corporations, and it was up to station engineers to collaborate with surveyors and try to induce them to reorganise their fleets and design vehicles suitable for removing dust, watering roads and sweeping. At Brighton they had had a vehicle on trial for a week for dust collection. It was put on every road in the town and upon some severe grades, and although it was not quite suitable for getting into the destructor and working at maximum efficiency for that reason, it had proved capable of negotiating the heaviest grades in Brighton, and, if it could do that there, it would do it anywhere else. There was a very big scope for vehicles of this class all over the country for the collection and removal of ashes, sundry road repairs, and so on. As to charging, station engineers must assist the people who were likely to use vehicles by making preparations for charging them. At Brighton he had an old boiler-house now dismantled at the main sub-station, which was fitted with a pit, and was capable of accommodating about twelve vehicles. There was ample plant capacity for charging at very reasonable prices, and as soon as a demand arose he was in a position to meet it. The Brighton Corporation had powers to

hire out motors, and he was sure his Committee would allow him to use money borrowed for this purpose, to provide suitable charging equipment in garages of breweries, laundries, etc., for charging vehicles on the user's premises. It could be done by simply making a reasonable charge or a hire-purchase rental, in the same way as for ordinary motors. There seemed to be unlimited scope, but it was only by pegging away at the thing that the business which he was sure was waiting would be obtained.

Mr. A. H. Shaw (Electrical Engineer, Ilford) said he was interested in Mr. Brydges remarks with regard to the cost of coal-carrying. He had gone very carefully into this, and had persuaded his Council to give an order for an electric wagon. The capacity for a wagon for this purpose was a matter for serious consideration, and he fixed on 4 tons for the reason that the coal trucks had 8 tons capacity, and thus he could empty a coal truck in two journeys. Unfortunately, owing to the position of his works, his coal had to be carted a distance of three-quarters of a mile from the nearest siding. It was impossible to get a siding into the works, or he would have done so long ago. Previous to the electric truck, the coal was carted by horses at a cost of 10d. per hour for 1½ miles, as against Mr. Brydges 1s. 6d. per ton for 2¼ miles. He therefore thought he got better results than Mr. Brydges did at Eastbourne. He anticipated that when this coal wagon was in full working order he would save no less than £120 to £150 a year on the cost of coal-carrying. Perhaps one of the reasons that better results were not obtained at Eastbourne was that coal was only carted there for about 200 days a year, and, of course, with an accumulator vehicle, it was necessary to keep it in commission as many hours as possible in order to get maximum economy. At Ilford he would be carrying 11,000 to 12,000 tons a year, and this meant that the wagon would not be laid up for any length of time at all. The figure of 10d. was a war price, the previous price being 7½d. in normal conditions. Similarly, an electric tower wagon which had been in use for eighteen months at Ilford had given every satisfaction and was considerably less costly than the previous horse vehicle. He did not agree with one remark of Mr. Chattock's on the question of tramways *v.* buses. Mr. Chattock had put it that batteries were not successful on tramcars, but that, because of this, there was no reason why they should not be satisfactory with ordinary road vehicles. Tramcars might be heavier than a good many other vehicles, but the tractive

force required was less owing to the rails, and he thought he was right in saying that it was now several years since a New York Tramway Company, owning a line running across the city, substituted battery tramways for mules, with the very best possible results.

Mr. G. Wilkinson (Chief Electrical Engineer, Harrogate) asked Mr. Shaw what the cost of his electric vehicle was, and the type of battery he was using.

Mr. Shaw said that the vehicle selected was an Edison battery wagon, and the total cost was £1,240. The figures of working costs had been worked out on a ten years' life.

Mr. W. H. L. Watson (Edison Accumulators) said a good many remarks had been made against the speed of the electric vehicle, but this matter had not been given proper consideration. The reason why an electric vehicle was so much cheaper than other vehicles in running costs was because they did not endeavour to exceed a suitable speed. If the petrol vehicle could run satisfactorily at the speed of the electric vehicle, there would be a much sterner fight between the two. Experience had taught those who were associated with the manufacturers that this extra speed was decidedly against economical running. If one stood in any city and watched the traffic, it would be noticed that a great number of the motor vehicles were not using the speed they had available. What was the good of having it if it could not be used. He had tried many experiments of following petrol vehicles from, say, Shepherd's Bush or the other side of London, to see how the electric vehicle fared in the matter of average speed, and although the petrol vehicle had been able when it could, to get away very much faster than the electric vehicle, nevertheless the latter got to a certain point sometimes in front of the petrol vehicle, and sometimes a minute or two behind, but never sufficient to make up for the extra cost of running the petrol vehicle. Another point was that central station engineers must admit they had too little experience generally of the running of vehicles to decide that, because an electric vehicle was so expensive, it was no good in their particular town. He had many times gone into towns as an absolute stranger, and had met the engineer, and had been told that there was not the slightest chance for an electric vehicle in that town. The engineer at times had been quite cool, not because he would

not help, but simply because he did not think there was anybody in his town who was sufficiently stupid to buy such an expensive vehicle. Going steadily to work, he had obtained introductions to the surveyor by the aid of the station engineer, and sometimes without his assistance, but he had been specially pleased when the latter accompanied him, because very often the result of the interview with the borough surveyor had been to cause him to change his opinion and become almost as keen as the manufacturers themselves. As a result, the engineer often introduced him to councillors and aldermen, and before he left the town he had got a half-promise that something might be doing shortly, and that very often had resulted in business. He mentioned this particularly because he did not want them to decide that price governed everything. The ultimate results were things to be looked to. Estimates which all makers of electric vehicles submitted were generally based on very careful lines. On account of the varying conditions in different towns they were obliged to give a running cost which they knew could be worked to. Users of Edison vehicles would admit that the estimates submitted for these had never been exceeded, and in many cases at least 10 per cent, saving had been shown. Before coming to any decision in these matters, he asked station engineers to send manufacturers full particulars of the work to be done, so that a price could be offered either on the basis of ton miles or vehicle miles. Notwithstanding the criticisms regarding price and speed, it was interesting to know that the railway companies were beginning to move in the purchase of electric vehicles. Several railway companies had bought platform trucks to start with, and now the Midland Railway Company had become buyers for twenty vehicles. These were not all Edison battery vehicles ; fourteen of them were, and the remainder were fitted with other types of batteries for experimental purposes. When railway companies bought expensive vehicles—and they are paying the same price which had been quoted to municipalities—it gives scope for reflection. Their method of buying was generally first of all to get hold of a cell and to do their utmost to spoil it. The Midland Railway Company had given an order for twenty vehicles after having had a vehicle on test. Other railway companies were also moving in the same direction, and, if they could make them pay, ordinary traders would. Another movement in the right direction was among brewers, and he had recently received orders from three or four leading breweries. One representative of a brewery came into his showroom and said he did not know anything about electric

vehicles, but when he was told that a certain firm of distillers had bought some, he immediately said that was good enough for him, and he ordered a vehicle on the spot. These distillers now had an electric truck running several weeks, and it was a fact that when their first bill for electrical energy for running the vehicle came in it was so small that they returned the account to know if it was correct. With regard to house refuse collection, reference had been made to using horses to go down the narrow back turnings and bring the material to a van or some shoot, and then remove it in larger quantities by a bigger electric vehicle. Last year he spent a lot of time in visiting different refuse destructors to ascertain the various methods of disposal and carting, and was troubled with the difficulty of the back lanes which were so often found in provincial towns. The matter had been thought out, however, and they had now brought out a small type of vehicle which was depicted on page 24 in the paper and which met the case very well. The capacity was approximately 2 cubic yards, but there was another type which took $4\frac{1}{2}$ cubic yards. The over-all cost of it, including capital, interest and maintenance, but not including labour, was £85 per annum, assuming that the vehicle lasted ten years, and that the mileage covered did not exceed twenty per day. He was rather inclined to think that the present method of handling house refuse was wrong, and had thought out a scheme, the idea of which was to have low-built platform vehicles moving about and doing the actual collection. On these platforms are placed two tanks, the total cubic capacity of which is $4\frac{1}{2}$ yards. Another heavier vehicle with a very large body is employed; it is fitted with a crane, which is used to empty the contents of these tanks into the larger body. The tanks are replaced on the platform trucks, and so the work proceeds during the day. Having received four or five loads in this manner, the big trolley proceeds to the destructor. Thus the system of each collecting van going to the tip and wasting a lot of time is avoided. This system is much appreciated by many officials. It can be worked at very material reductions in cost compared with previous methods. He believed that the electric vehicle would monopolise that class of business during the course of the next few years. As to battery trams, there were not very many working at present, but those that were in operation were giving every satisfaction. In America there were quite a number of light railways, the vehicles of which were heavier than the ordinary type of tramcar, and were doing forty miles an hour on very low running costs and equally low maintenance. They were

certainly costly in the initial stages, but the economical running costs counterbalanced this.

Mr. W. Wyld (Member of Council) (Chief Electrical Engineer, Hampstead), said that he had given consideration to this matter for some years, but found some difficulty in getting his Corporation to make a start. The first answer met with when a tradesman was asked was, " Why do you not use them yourself ? " Unfortunately the Electricity Department at Hampstead was not quite large enough to find use for such a vehicle and he tried to get the Borough Surveyor's Department, which had a large stud of horses, to purchase one. Unfortunately, some years ago the Hampstead Corporation tried some steam vehicles with disastrous results, and had replaced them by horses, and consequently there was great difficulty in persuading the Borough Engineer's Department to buy an electric vehicle. He, therefore, had been compelled to tackle it something on the basis of electric cooking apparatus. No progress could be made in this direction unless the apparatus was hired out, and so he approached the Works Committee through the Borough Surveyor and was able to induce that Committee to hire an electric vehicle which was to be purchased by the Electricity Committee. A trial showed that the vehicle could do at a cost of 19s. 6d. per day inclusive of capital charges, what it was costing 35s. at present. The cost of the vehicle was approximately £1,000, and he had practically come to an agreement with the Works Committee for the hire of the van and a man to drive it on the basis of a certain number of days per annum for four years, and the price charged would provide for the purchase of the machine in four years, so that the Electricity Department would have a vehicle which it could use to a certain extent during the year, whilst the hire by the other departments would repay the cost and leave the Department with the vehicle at the end of the hiring period. Meantime the vehicle would be invaluable as an advertisement for the electric lighting department.

A Member asked Mr. Brydges the quantity of coal that he carted per annum with his steam wagon, also did he use the wagon for any other purpose than coal carting ?

Mr. Brydges, said the wagon was in use for 202 full working days during the year, an average of four days a week, and cleared 1,215 tons. It was used for no other purpose as a general rule. There had only been occasion to use the wagon for one other

purpose during the past year when a 200 kw. steam alternator was carted in parts to the railway station. No other form of vehicle could have been so conveniently manœuvred in the small space available.

Mr. A. E. Meaden, (Wolseley Motors, Ltd.) said he was in rather a unique position inasmuch as he was interested in both petrol and electric vehicles. He could not help feeling that municipal engineers should not go too keenly into the question of speed. He was absolutely confident that on the speed question the electric vehicle had no chance whatever with the petrol vehicle. The two fields of usefulness did not coincide in any way whatever. The electric vehicle had a field entirely of its own, and there was undoubtedly a very large market in England for this vehicle in its own field. In competing with petrol vehicles the electric vehicle was up against something it would never get over. The petrol vehicle was the one for mileage and carrying loads for long distances. The electric the one for short journeys and constant stops. He did not think the electric vehicle was the ideal pleasure vehicle. It might be the Town coupé, but it was not the pleasure vehicle. Speed was everything with the petrol vehicle ; speed was everything against the electric vehicle. At speeds over twelve miles an hour it would be found that depreciation and maintenance charges would rapidly increase, because the vehicle was being used for something for which it was never intended. The reason why electric lorries were largely used in America was because there were few good roads connecting the towns, and in consequence the petrol lorry had never had a chance. Therefore people had bought, and engineers had devoted themselves to the production of electric vehicles because they were the most economical for use in city areas. There were many people in England to-day who could with great advantage use a mixed fleet of petrol and electric vehicles and the reason why petrol vehicles were used in spheres which were not their own, was simply because the user had both classes of jobs to do and he bought the machine which would do both. The electric vehicle would not do both. His firm were large manufacturers of petrol vehicles, but they had now taken up electrics and were importing machines from America, with the intention of finding out if there was a market and if there was, to meet it. He was in agreement with municipal engineers on the question of price. It was very much too high and would have to be reduced considerably. As manufacturers of petrol vehicles his firm was faced with the anomaly that although the mechanical

parts used in the construction of the petrol vehicle were greater than those in the electric, yet petrol vehicles could be purchased very much cheaper. This was a question which must be gone into, and although as a salesman perhaps he was "queering his own pitch," nevertheless as an engineer he must look on it in that light.

Mr. W. A. Walker (Electrical Engineer, Kettering Urban District Council) (*Communicated*) says he considers that manufacturers of electric vehicles should be more speculative and not wait for municipalities to come to them with orders, also, when requested, be prepared to loan a vehicle on a week or fortnight's trial. A firm was asked to do this for his Council, but they could not see their way. He considers this very short-sighted policy.

He would be glad if the author could give any information regarding electric tractors for hauling wagons (*see* Fig. 19) as he has been led to understand that electricity was not very suitable for this purpose. He thinks this is a point which should be cleared up if electricity is to cope with steam for this class of work.

Mr. F. Ayton, in reply, said there was one thing he could never understand and that was the frame of mind of the electrical man who carried about with him a wet blanket, always ready to cast it upon any new idea. He thought they could all agree with him that that had been the curse of the electrical industry from its earliest days in this country, and it went a long way to explain why we had not gone ahead to the same extent as the enterprising young nation in the West. Out there the feeling was that it was necessary to talk of things electrical all the time, and they must not be afraid of making mistakes. Some people went about with a wet blanket simply because they were afraid of making a mistake, but he believed it was an old saying that a man who never made a mistake never made anything. If they were to go ahead with these things and make a huge success of the business they must be enthusiasts. We must recognise, as Mr. Meaden had so clearly pointed out, that there was a place in the sun for each type of vehicle, and that each had its own peculiar field. It would only do harm to the cause of the electrical vehicle if there was irresponsible enthusiasm in connection with it, in other words the danger lay with the man who would recommend the electric vehicle for every possible service. It was essentially a moderate speed vehicle and a vehicle for use in short haulage work, and in this sphere it could show results that were untouched by any other type. With regard to price, everyone must agree

that the price had to come down, but, nevertheless, business could be done on present prices and they should endeavour to do so, because after all the question of price went with the extent of manufacture, and until there was a bigger demand he did not think the price would come down very much. No doubt it is coming down to some extent with the manufacture of vehicles in this country, but what was wanted now was to increase the demand so that the manufacturers could turn out more machines. Mr. Wordingham had compared the unfortunate results of years past with battery-driven tramcars, but in his opinion it was the greatest mistake in the world to go back a few years, especially in electrical work, and compare things which were done then with things which were done to-day. In no industry had progress been so rapid and change so frequent as in the electrical industry. In the early days the batteries were not suitable for their work the mechanism was inefficient, and everything as we judged to-day, was out of date. The electric vehicle of to-day was a different machine altogether to the machines which were on the streets a few years ago. Mr. Cooper, of Wimbledon, had touched upon a very important point, namely the proper design of vehicles to suit them for municipal work. It was a very important point, getting the body of a dust van low enough down. There was, however, a vehicle being designed in this country with a front wheel drive—in fact there were two makes already on the market, or about to be put on the market—where the front wheel drive enabled a very low body to be used. The electric vehicle, however, was working under disadvantages in the matter of first cost, and the Committee would keep the points which had been raised in view.

As to the electric supply undertaking dealing with the business, he had referred to that before, but it was so important he would like to deal with it again. It was absolutely essential that if they were going to do any business at all, the Supply Department must use the vehicles itself, or if it could not afford to run one, get one of the other departments to do so. In addition to that they must use proper means of suggesting to the possible users in their districts the advantages of the electric vehicle. The Electric Vehicle Committee had gone to some trouble to provide suitable literature for that purpose, and although it had been used to some extent, the Committee wanted it used to a very much greater extent. It did not cost very much, and it would be found that results were obtained which would pay many times over for the small expenditure entailed. Going to another part of this question he would like to acknowledge the financial

assistance which Corporations had so willingly given to the Committee in the past year. The Committee was deeply grateful for that assistance and hoped that the Corporations and others would recognise the value of the work which had been done, and the necessity for making it continuous, and in order to make it continuous to repeat the donations they had given in the past year. In dealing with the question of coal haulage, Mr. Brydges had stated that the electric vehicle was limited in capacity. That was a wrong impression. Vehicles had to be built to carry up to 10 tons, and this was more than was generally needed for the heaviest work. If anyone had any difficulty in getting quotations for such a vehicle and would communicate with the Committee, he thought they could give some assistance in the matter. Comparisons had been made between the trackless trolley bus and the battery electric bus, but he did not think they could be very well compared. The trolley bus was fixed to its route, whereas the battery bus was entirely mobile, and could be taken off one road and put on another, which was a great advantage. As to the standard plug, the Committee regarded it as most important that where facilities were provided for charging, the standard plug should be used, and if vehicles were found not employing these standard receptacles, the supply authority should insist upon the owners using them so that there might be uniformity in that direction throughout the country.

In regard to Mr. Walker's call for greater enterprise on the part of firms selling electric vehicles, it has to be remembered that there are but few firms at present working the electric vehicle field in this country and practically every one of these has had its time fully occupied in dealing with the multitude of enquiries that have been received from other larger towns and cities. It is but natural, seeing that the business prospects of the moment are immeasurably greater in these places, that the firms should, for the time being, concentrate their energies and attention upon them in preference to tackling the smaller centres. In the course of time, no doubt, any cause of complaint, of the nature mentioned, will disappear.

As to Mr. Walker's question regarding electric tractors, the author regrets he is unable to present any figures relating to the cost of operation. Undoubtedly the energy consumption is greater, for equal weight handled as load, as compared with the electric waggon, and the employment of a tractor seems justified only in special circumstances where arrangements can be made to keep it in more or less continuous operation by having one or

more spare trailers always loading and unloading so that there is no waiting at either end of the journey.

The Chairman said that the Electric Vehicle Committee was mainly due to the energy of Mr. Ayton and the amount of work that he had put into the Committee was enormous. He proposed a hearty vote of thanks to him for this work and also for the very useful paper which he had put forward. The vote of thanks was carried with acclamation.

At the conclusion of the discussion upon the Electric Vehicle Committee's report, the members adjourned to the Victoria Embankment for the purpose of inspecting an exhibit of electric commercial and pleasure vehicles arranged by the Committee. The vehicles which were shown are described in the list below :

	Reference Letter for Method of Control.	Transmission.	Tyres.
	B	Spur and idler gear in rear wheels ..	Solid.
	B	Chain drive	Ditto.
	A	Ditto	Pneumatic.
	—	Worm drive live axle	Solid.
	—	Chain drive	Ditto.
	C	Bevel gear jack shaft and roller chains to rear wheels.	Ditto.
o	C	Ditto	Ditto.
	C	Worm gear live axle	Pneumatic.
	C	Ditto	Solid.
	—	Chain drive	Ditto.
	—	Ditto	Ditto.
	B	Worm drive live axle	Pneumatic.
	A	Chain drive	Ditto.
	A	Ditto	Ditto.
	D	Helical gear	Ditto.
	—	—	—
	E	Single reduction spur gear	Ditto.
	—	Worm drive live axle	Ditto.
	—	Ditto	Ditto.
	—	Chain drive	Solid.

unting field coils.
nd field coils combined with resistance steps.

No.	Exhibited by	Type of Vehicle.	Carrying Capacity.	Speed on Smooth Level Road.	Battery.			Reference Letter for Method of Control.	Transmission.	Tyres
					Make.	No. of Cells.	Capacity in A.H			
				m.p.h.						
1	Harrods, Ltd.	Walker covered delivery van	10 cwts.	14	Edison	60	220	B	Spur and idler gear in rear wheels	Solid.
2	West Ham Corporation	Open body waggon	20 ,,	11/12	Ditto	60	225	B	Chain drive	Ditto.
3	St. Marylebone Council	"Opel" covered delivery van	10 ,,	12	Hart, lead	52	120	A	Ditto	Pneumatic.
4	General Vehicle Co., Ltd.	Covered delivery van	9 ,,	15	Ironclad-exide	44	133	—	Worm drive live axle	Solid.
4A	Ditto	Chassis	40 ,,	12	—	—	—	—	Chain drive	Ditto.
5	Edison Accumulators, Ltd.	Patent automatic tipping refuse van	40 ,,	12/13	Edison	60	300	C	Bevel gear jack shaft and roller chains to rear wheels.	Ditto.
6	Ditto	Type G.M. Edison chassis	20 or 40 cwts.	12/13	Ditto	60	225 or 300	C	Ditto	Ditto.
6A	Ditto	Edison Limousine	—	15/18	Ditto	60	—	C	Worm gear live axle	Pneumatic.
7	J. Pullar & Sons, Ltd. (Perth)	Covered delivery van	20 cwts.	12	Ditto	60	300	C	Ditto	Solid.
8	Wolseley Motors, Ltd.	Baker chassis with box van body	20 ,,	10½	Ironclad-exide	42	157	—	Chain drive	Ditto.
9	Ditto	Baker chassis	40 ,,	9	Ditto	42	189	—	Ditto	Ditto.
10	Croydon Corporation	Roadster passenger car	3 people	18/20	Edison	60	150	B	Worm drive live axle	Pneumatic.
11	Poplar Borough Council	"Opel" covered delivery van	10 cwts.	12	E.P.S. Co.	44	125	A	Chain drive	Ditto.
12	Heston and Isleworth Council	"Opel" light delivery van	15 ,,	14	Hart, lead	44	120	A	Ditto	Ditto.
13	Hertford St. Motor Co., Ltd.	Electric landaulette	4 people	15/20	Lead plate	45	150	D	Helical gear	Ditto.
13A	Ditto	Ditto, chassis only	4 ,,	—	—	—	—	—	—	—
14	Krieger Electric Carriage Syndicate	Electric landaulette	4 ,,	20	Naylor, lead	46	175	E	Single reduction spur gear	Ditto.
15	Heath's Garage, Ltd., Birmingham	"Milburn" Coupé	4 ,,	20	Philadelphia, lead	20	204	—	Worm drive live axle	Ditto.
16	Ditto	"Lang" Coupé	4 ,,	24	Ironclad-exide	41	137·5	—	Ditto	Ditto.
17	Wolseley Motors, Ltd.	Baker electric lorry	70 cwts.	8/9	Ironclad-exide	42	—	—	Chain drive	Solid.

Explanation of Reference Letters in List.—The reference letters in the column headed "Method of Control" have the following meaning:—

A.—Series parallel arrangements of battery in two sections with resistance steps.

B.—As A, but with addition of series parallel arrangement of field coils.

C.—Battery in series with series parallel arrangement of field coils combined with resistance steps in main circuit and arrangement for shunting field coils.

D.—Double wound armature and two commutators. Battery permanently in series. Series parallel arrangement of armature windings and field coils combined with resistance steps.

E.—1st step. Two sections of battery in parallel and two compound motors in series.
2nd step. Same as 1st step, but shunt windings cut out, making two series motors in series.
3rd step. Battery in series and two compound motors in series.
4th step. Same as 3rd step, but shunt fields cut out.
5th step. Battery in series and two compound motors in parallel.
6th step. Battery in series, shunt windings cut out.

Incorporated Municipal Electrical Association.

TWENTIETH ANNUAL REPORT OF THE COUNCIL,

From June, 1914, to June, 1915.

(*Submitted to the Annual General Meeting in London, on Friday, June 18th,* 1915.)

CONVENTION, 1915.—The Council, in presenting their Annual Report, desire to place on record the circumstances which have affected the arrangements made for the 1915 Convention. The President, Major H. Richardson, having intimated that if the Council decided to hold the Convention at Dundee the Association would be sure of a very hearty welcome from his City, the Council agreed that the Convention for 1915 be held in Dundee.

Before further arrangements were made war was declared, and a letter was received from Major Richardson to the effect that he had been called up for War Service, and would be unable to attend any meetings until after the termination of his military duties.

In the enforced absence of the President, the Council appointed Mr. A. C. Cramb (the Senior Vice-President) as Acting President during Major Richardson's absence on War Service. The President at the same time expressed the view that the Convention should be postponed, but that the ordinary work of the Association should proceed as usual.

Under the Articles of Association it is necessary to have an Annual Meeting, and the Council therefore resolved that the usual Convention should not be held in 1915, but that the Annual Meeting be held in London instead of Dundee as previously arranged. It was further resolved to arrange a business meeting to occupy two days, and that no social functions should be held. It was decided that the attendance at the meetings be restricted to Members and Official Delegates of Local Authorities, and to Members of the Electric Vehicle and Development Committees.

The Council of the Institution of Electrical Engineers has again very kindly placed the Institution premises at the disposal of the Assocation for its meetings.

Office of President, 1915-16.—Since it has become evident that there is little likelihood of Major Richardson being able to give his services to the Association throughout the ensuing year if he were re-elected to office, his views have been ascertained, and in conformity with the same the Council suggest that his name should be placed on the list of Past Presidents, and they record their desire that at the first opportunity he should be nominated for another term of office as President.

The membership of the Association now stands at 377 made up as follows :

Committees (Members)	166
Chief Electrical Engineers (Members)	174
Honorary Members	6
Chief Assistants (Associate Members)	4
Assistants (Associates)	27
	377

After allowing for deaths, resignations, removals, and lapses due to members leaving Municipal employ, there is a decrease of two on last year's total.

Since the publication of the last Annual Report, the Council had held nine meetings. These have been held in London with the exception of one held in Birmingham. There have been also a number of meetings of Standing and Special Committees and Sub-Committees appointed to deal with specific matters. These Committees have met and reported to the Council periodically on the matters referred to them.

By the courtesy of the Council of the Institution of Electrical Engineers, the Council and Committee meetings in London have been held at the Institution's headquarters.

The attendances of members of Council are set out in the following schedule :

	1914.				1915.					
	June, Birmingham.	July, London.	October, London.	December, London.	January, London.	February, London.	March, London.	April, London.	May, London.	Maximum possible.	Actual.
Ayton, F., Ipswich	×	×	×	×	×			×		9	8
Beauchamp, J. W., West Ham	·	×	×	×	×	×	×	×	×	8	8
Blackman, A. S., Sunderland	·	×	×	×	×	×	×		×	8	7
Christie, J., Brighton			×	×	×	×	×	×	×	9	8
Cramb, A. C., Croydon	×	×	×	×	×	×	×	×	×	9	9
Chattock, R. A., Birmingham	×	×	×		×	×		×	×	9	7
Crowther, Councillor, Sheffield	·	×	×	×	×	×		×	×	8	7
Edgcome, J. E., Kingston-upon-Thames	×	×	×	×		×	×	×		9	5
Ellaway, Alderman, Birmingham	×	×	×	×	×	×	×	×	×	9	6
Fedden, S. E., Sheffield	×	×	×	×	×	×	×	×	×	9	9
Furness, C. Blackpool	×	Time expired.									
Gibson, Councillor, Wolverhampton	×	—	—	×			×			9	3
Lackie, W. W., Glasgow	×	Time expired.									
Long, F. M., Norwich	·		×	×	×	×		×	×	8	6
Nairn, Bailie, Dundee	·									8	0
Pearson, Alderman G., Bristol	·				×					9	2
Proctor, H. Faraday, Bristol	×		×	×	×	×	×	×		9	8
†Richardson, H., Dundee	×	×	×			×	×	×	×	9	8
Roles, T., Bradford	×	×	×	×	×	×	×	×	×	9	8
Seabrook, A. H., London	×	×	×							9	8
Sinclair, Councillor, Swansea	×				×	×	×			9	1
Smith, Alderman, J. P., Barrow	×		×		×	×	×		×	9	6
Smith, Bailie, W. B., Glasgow	·	×	×	×	×	×	×	×		8	7
†Vignoles, W. A., Grimsby	·	×	×	×						8	1
Wilkinson, G., Harrogate	·	×	×	×	×	×	×	×	×	9	9
Watson, S. J., Bury	×	×	×	×	×	×				9	7
Wyld, W., Hampstead	×	×	×	×	×	×				9	8

† On Active Service.

Model General Conditions of Contract.—It will be remembered that upon considering the Model General Conditions of Contract placed before the Annual General Meeting in June, 1913, and further considered at a subsequent Extraordinary General Meeting held in the following month, it was resolved that the Association of Municipal Corporations should be consulted and that until the report of a Joint Committee, composed of members of that Association and of the I.M.E.A., had been laid before the General Body of Members, the Council were not to communicate with the B.E.A.M.A., or any other Body, on the question.

The Association of Municipal Corporations was immediately approached, but that body did not move very quickly, and it was not until the day before the Annual Meeting of 1914 that the Council received from the Association of Municipal Corporations a proof of the document as they had amended it. Even then it had not been submitted to the governing council of that body, but only to the Legal Council, and was the outcome of a joint meeting between representatives of the Association of Municipal Corporations and of the I.M.E.A. Council held six months previously.

In the meantime the Council of the B.E.A.M.A., which had not at that time been consulted by the A.M.C. regarding the proposed amendments, decided to adopt the Model General Conditions as issued by the Institution of Electrical Engineers for a period of one year in respect of municipal contracts in order to see how they worked. The B.E.A.M.A. asked for the views of the Council upon this proposal, and enquired if they would fall into line with it, Under the circumstances no reply could be given, and the matter is left as heretofore for each corporation to deal with the manufacturers direct.

The A.M.C. has since been in negotiation with the B.E.A.M.A. but arrangements have not reached a report stage.

I.M.E.A. Bill.—At the last Annual General Meeting it was decided that steps should be taken to ascertain which of the municipalities represented in the Association would co-operate in the promotion of a Joint Private Bill, and early in October the Members of the Association were asked whether their respective Authorities would support such a proposal. The Council, having given further careful consideration to the matter including the various observations made in reply to the circular letter, decided that no further action be taken in connection with the suggestion for a Joint Private Bill, and that the Association revert to the pressing forward of a Bill promoted in the manner originally arranged.

The following suggestions from members and from Power Companies for further Clauses to be added to the Bill have received consideration by the Council:

"Words to be inserted to make it clear that the powers of the Bill are to be in addition to, and not in substitution for, any powers already held by undertakers."

"Clause to authorise special systems of charging based upon electrical assessment."

"Compulsory way-leaves."

"Power to Companies to supply electricity for lighting throughout their power supply areas."

The Acting President, Mr. A. C. Cramb, had an interview with Mr. Rawlings, the President of the Electrical Contractors' Association, as a result of which the Council decided that no further concessions be made beyond those contained in the Bill as last printed.

After careful consideration of the results of the I.M.E.A.'s Parliamentary Propaganda in support of the Bill, Messrs. A. C. Cramb, Bailie Smith, A. H. Seabrook, S. E. Fedden and H. Faraday Proctor, were appointed as a Sub-Committee to meet the B.E.A.M.A. with a view of discussing this question with them.

Particular attention is drawn to the fact that the Corporation of Glasgow has arranged terms upon which it will operate its Publicity and Sales Departments. The Electrical Contractors' Association in Scotland have agreed to terms less advantageous to themselves than those to which the Electrical Contractors' Association take exception in the Bill.

Delegates' Expenses.—The Association is represented by the Acting President, Mr. A. C. Cramb, on the Committee formed by the Royal Sanitary Institute to consider the question of obtaining powers for Local Authorities to pay delegates' expenses to Annual Conferences. The Local Government Board held the view that such Conferences are not all conferences within the meaning of the Local Government Public Health and Conferences Act, 1885.

A deputation from the County Councils' Association waited upon the President of the Local Government Board in January of last year in support of the Bill to legalise such expenses, and the President of the Local Government Board intimated that there was some ground for standardising the objects of conferences to which Local Authorities may send representatives, and that a more elastic interpretation by the Auditors might be desirable.

The Joint Committee made certain suggestions for the limitation of Congresses and the number of Delegates attending, and agreed to approach other Associations of Municipal Authorities to secure their support with a view to arranging some combined action in submitting their proposals to the Local Government Board.

The Joint Committee communicated with the Association of Municipal Corporations, the Association of Port Sanitary Authorities, and the Metropolitan Borough Councils Standing Joint Committee, and also with the Urban District Councils' Association and the Rural District Councils'

Association, to ascertain if they would be willing to use their influence in bringing the matter before the Local Government Board.

Engineering Standards Committee.—A year ago the Association was invited by the Engineering Standards Committee to nominate two members to represent them on the newly-constituted Sectional Electrical Committee. Mr. A. H. Seabrook and Mr. A. C. Cramb (Acting President), were nominated, and at the first meeting additional representation was obtained of two members on each of the sub-committees dealing with Electric Power Cables, and with Prime Movers for Electrical Plant.

Subsequently as a result of suggestions kindly made by Sir John Snell regarding the question of representation of the I.M.E.A. on the sectional committee and on some of the sub-committees and panels, the following representation was arranged :

Sectional Committee and B.N.C.	Mr. Chattock and Mr. Seabrook.
Standardization of Rules for Electrical Machinery	Mr. Christie.
Electric Lamps	Mr. Fedden and Mr. Wilkinson.
Electric Power Cables	Mr. Cramb and Mr. Wyld.
Electrical Accessories	Mr. Cramb and Mr. Seabrook.
Prime Movers	Mr. Long and Mr. Faraday Proctor.
Panels of the Sub-Committee on Electrical accessories :—	
(*a*) Plugs	Mr. Cramb and Mr. Seabrook.
(*b*) Switches	Mr. Cramb.
(*c*) Fuses	Mr. Wyld.
(*d*) Heating and Cooking	Mr. Seabrook.
(*e*) Carbon brushes, control gear and electric vehicle accessories	Mr. Ayton.
(*f*) Meter Panel	Mr. Beauchamp.

The Council has since voted a sum of twenty guineas from the funds of the Association as a donation from the I.M.E.A. to the Engineering Standards Committee which receives considerable subsidies from the other bodies represented thereon.

It is with regret that the Council learn that the response to the appeal for subscriptions made by the Engineering Standards Committee has been very poor from Municipal Electrical Undertakings. The Council feel that perhaps it is not realised how specially valuable the work done by the Standard Committee is to Electrical Engineering Undertakings, how the standardisation of apparatus cheapens the cost of its manufacture, and reduces the time taken in the preparation of Specifications by the Engineers in charge of such undertakings.

They wish, therefore, to make a special appeal to the Committees who control Municipal Electrical Supply Undertakings, to give their generous support to the Standards Committee by making an annual subscription towards the Fund.

Development Committee.—The following resolution was passed at the last Annual General Meeting:

> "That a Special Committee be formed of members of this Association, not necessarily Members of Council, to deal with any matters that may tend to encourage the use of electricity from the public supply mains, and that this Association shall invite other Associations and persons who can assist in furthering the object for which the Committee is formed, to join such Committee."

At the first Council meeting of the session a special committee was formed in accordance with the terms of the resolution, and was invited to prepare a scheme for the consideration of the Council. Mr. Vignoles was appointed Hon. Secretary of the Committee, but had volunteered and been accepted for War Service. At the request of the Council Mr. J. W. Beauchamp accepted the Hon. Secretaryship of the Committee for the time being. Representatives of kindred associations, and other persons likely to be of service were co-opted as members and the work so far accomplished is set out on the Development Committee's Report which forms an addendum to the Council's report.

Long Eaton and Ilford Cases.—In regard to the Ilford case it was represented to the Council that in view of the judge's opinion further technical evidence was necessary, and that it would be desirable to retain a Leader with special knowledge of the Electric Lighting Acts. The Association and other interested bodies were asked for some contribution towards the extra cost.

The Council after due consideration asked the Hon. Secretary to draw up a statement as to the danger of the Gas Company's attack, and circulate it to the Local Authorities represented in the Association, asking them to contribute to the expenses of supporting a test case, and inviting those Members of the Association who would be prepared to give voluntary evidence to send in their names. Considerable financial support was promised in response.

Mr. Faraday Proctor subsequently presented a valuable report on the subject to the Council. Having carefully examined the tariffs of over one hundred of the municipal undertakings, he was of opinion that there were only a few which might be subjected to attack on the grounds of the objections alleged in the Long Eaton and Ilford cases. Some of these cases were at the time receiving consideration with a view to amendment, and in other cases the Engineers were prepared to recommend amendments if such were thought desirable. The ground would therefore appear to be clear at least as regards the tariffs put forward by the large number of Members who replied to the letters of enquiry.

Yorkshire Electric Power Company's Bill.—With reference to the moral support given by the Council to the petitions against the Bill by certain Municipalities, as set forth in the last Report, a communication was subsequently received from the Association of Electric Power Companies in regard to the attitude of the I.M.E.A. in advising the Local Authorities in the Yorkshire Electric Power Company's Area to oppose the Bill. It was suggested that the I.M.E.A.

had not realised that the Yorkshire Electric Power Company were only seeking to get Lighting Powers in the areas in which under their existing Acts they could already supply power. This materially altered the position, and steps were at once taken to make it clear that if the I.M.E.A. had been informed at the time as to the limits of the Powers sought by the Yorkshire Electric Power Company active opposition would probably not have been given.

The chief points raised by your Council were :

(*a*) Whether any of the areas referred to in the first schedule in the 1915 Bill were included in the Supply Areas of any Undertakers, Municipal or otherwise.

(*b*) The consideration of the question of those portions of the Areas which bordered upon the existing Supply Areas of other Undertakers.

Concerning (*a*) the Council were informed that the reply was in the negative, wherever Powers had been held they had lapsed and been cancelled.

Concerning (*b*) the Council were of the opinion that, inasmuch as it was desirable to avoid unnecessary duplication of electricity supply mains in any area, the proposals of the Bill were reasonable, provided that satisfactory protective Clauses were inserted.

The larger towns affected, such as Bradford, Doncaster, Dewsbury, Hull, Leeds, Middlesbrough, Rotherham, Sheffield, and Wakefield, were communicated with, and informed of the views of the I.M.E.A. on the matter.

The Select Committee of the House of Lords, to whom the Bill was referred, after hearing evidence on behalf of the promotors and from the Board of Trade, announced that the Bill could not proceed as regards the clauses, which the Company considered of primary importance. The measure was thereupon withdrawn.

Lamp Specifications.—The Tungsten Lamp Association invited the Council to send representatives to form a Joint Committee to discuss the outlines of the specification proposed to be put forward by the Tungsten Lamp Association. As the Council were already represented on the Sectional Committee of the Engineering Standards Committee dealing with a similar subject, they did not see that any useful purpose would be served by meeting the Tungsten Lamp Association, bearing in mind the views which the I.M.E.A. representatives held on the matter.

Electric Vehicle Committee.—The report of this Committee will be found attached to this Report for the information of the Association.

Sir John F. C. Snell. — The Council records with satisfaction and pleasure the honours conferred upon Mr. J. F. C. Snell, a Past President of this Association, his Majesty the King having bestowed knighthood upon him in recognition of his services to the electrical industry, and the Institution of Electrical Engineers having elected him as their President.

Smoke Abatement.—The Council felt that Electric Supply Undertakings were especially interested in the question of Smoke Abatement, and they approached the Smoke Abatement Committee offering to give evidence on the subject through the representation of Mr. Chattock and Mr. Seabrook. This was to have been taken in the autumn of last year, but the work of the Committee is now in abeyance pending the termination of the war.

L.G.B. Loans.—The Council has had under consideration the action of the Local Government Board in refusing loans for extensions, etc., owing to the war. After most careful deliberation and consideration of the subject from all points of view, including that of the desirability of bringing the war to a successful conclusion at the earliest possible date, the Council felt that they could not recommend

action being taken on general lines. It was thought that the case of each undertaking should be considered upon its merits.

The question is now being dealt with by the Association of Municipal Corporations and the Institute of Municipal Treasurers and Accountants.

The membership of the Association was circularised upon this question, and about sixty-five replies were received by the Honorary Secretary, who forwarded particulars of all the urgent cases to the proper quarter for presentation to the Local Government Board by a deputation.

Foreign Manufactures.—In response to a circular letter sent to 195 towns represented in the Association (Chairmen and Engineers), forty-four replies were received, to the following effect :

20 had some difficulty in obtaining certain goods.
8 had sufficient stock for the present.
15 had no difficulty.
1 was giving the matter consideration.

151 have not yet replied.

The chief articles regarding which difficulty was experienced were in connection with the supply of Lamps and Carbons.

The matter was subsequently referred to the Development Committee for consideration and report.

War Office and Enlistment.—With the object of ensuring that members of the staff of Electricity Undertakings should not be accepted for enlistment without special permission, the War Office had been approached pointing out the desirability of preventing the depletion of

the staff below the minimum necessary for the carrying on of the Works of Electricity Departments. The War Office agreed that those who were of necessity engaged on such works were doing equal service to the country as those who had enlisted. The War Office has given consideration to the question of issuing a badge or certificate of exemption, but could not see its way to fall in with the proposal.

Joint Motor Committee.—The B.E.A.M.A. invited the Council to appoint four members to form a Joint Motor Committee. Messrs. A. C. Cramb, A. H. Seabrook, S. E. Fedden, and J. W. Beauchamp were appointed to represent the I.M.E.A. The suggestion of the B.E.A.M.A. was that there should be a standard specification which should be adopted by the I.M.E.A., and that an arrangement should be made as to preferential discount to undertakings in their districts where such undertakings have the power to sell motors.

The Joint Committee eventually recommended that the I.M.E.A. and B.E.A.M.A. should adopt a standard specification for direct current motors, preferably that to be issued by the Engineering Standards Committee, and until this was issued, the B.E.A.M.A. Motor Specification.

The Council have suggested several modifications to the specification, and the matter is still under consideration.

Board of Industry.—Messrs. H. Faraday Proctor, S. E. Fedden, A. H. Seabrook, A. C. Cramb and Bailie Smith attended on behalf of your Council a joint meeting of representatives of the B.E.A.M.A. and the British Engineers' Association to consider the question of the protection of British interests.

Proposals were made for the formation of a Government Department to be entitled the Board of Industry, or alter-

natively the appointment of a fully representative committee. The former course was adopted, and it was decided to invite the I.M.E.A. to appoint a representative on the joint committee, one of the main objects being to secure the principle that public money should be expended only on British manufactures. Mr. A. C. Cramb (Acting President) was appointed to represent the Association.

The following resolution was passed subsequently by the joint meeting and the Associations represented were asked to adopt it :

> " Resolved that this Association, fully recognising the necessity for the creation of a new Government Department whose sole function it shall be to safeguard and promote the industries and commerce of the British Empire, is prepared to co-operate with those other Associations who, on the invitation of the British Engineers' Association, have signified their general approval of its proposals that a scheme for the purpose should be prepared and brought before the Government.
>
> It is further resolved that this Association shall nominate representatives not exceeding two to act on a Joint Committee for this purpose and of inviting the co-operation of any further bodies or individuals whose services may be of use in the forwarding of this movement and that Messrs. and be hereby nominated representatives of this Association on the aforesaid Joint Committee."

The Council appointed Messrs. A. C. Cramb and Thomas Roles as their representatives on the Joint Committee, now designated the Board of Industry Committee. The Council, through its representatives, is watching the interests of municipal electrical undertakings.

National Proving House.—A communication from Mr. Wordingham (Past President) on this subject was referred to the Development Committee for consideration and report.

Municipal Loans. — The Institution of Electrical Engineers submitted to the Council a copy of a report of

the Municipal Loans Committee of the I.E.E., which with slight amendment had been adopted by that body. The I.E.E. Committee were preparing a memorandum for presentation to the Local Government Board on the matter.

The Council after due consideration supported the recommendations made by the Institution of Electrical Engineers, in regard to the periods allowed for the repayment of loans :

	Periods recommended. Years.
(*a*) Cables substantially constructed and laid	30
(*b*) Conduits substantially constructed	60
(*c*) Accumulators and batteries in cases where the sanctioning authority is satisfied that adequate provision has been made for the proper maintenance of the batteries	15
(*d*) Reinforced concrete	30

Institution of Electrical Engineers Benevolent Fund.—In response to the recent appeal issued on behalf of this fund the Council decided to subscribe a sum of £10 10s. from the funds of the Association. This gives the Association ten votes for the year in addition to which the Association has ten votes for life in respect of its donation of £50 made in 1902, when it was decided to close the Benevolent Fund of the I.M.E.A. and hand the amount in hand over to the Institution.

Hon. Treasurer's Report for the Year ended March 31st.—The income from subscriptions remains normal and there is a considerable increase in the revenue from the proceedings (sales and advertisements). The increase in the outgoings for printing is due chiefly to the size of the proceedings which always vary in bulk. There is a surplus for the year of £62 against £65 last year. The total surplus of assets over liabilities is £848 and £100 has been invested in War Loan Stock bringing the invested funds to, say, £700, the present market value of which is £635. It will be noted that there are no bad debts and that so far the War has

had no detrimental effect on the Association from a financial point of view.

The Council's report would be incomplete without some reference to the time which its members devote to Committee work in addition to that involved in the Council meetings. They would specially refer to the large amount of honorary secretarial and organisation work undertaken with great advantage to the Association and the Committees concerned by Mr. H. Faraday Proctor, the Hon. Secretary of the I.M.E.A., Mr. Frank Ayton, the Hon. Secretary of the Electric Vehicle Committee, and Mr. J. W. Beauchamp, the Acting Hon. Secretary of the Development Committee.

INCORPORATED MUNICIPAL

INCOME and EXPENDITURE ACCOUNT

The Bold Figures are for the twelve

1914. £	s.	d.	EXPENDITURE.	£	s.	d.	1915. £	s.	d.
			To General Expenses—						
19	0	0	Reporting and Clerical Assistance	10	11	7			
0	11	0	Bank Charges	1	1	3			
4	4	0	Audit Fee	4	4	0			
63	7	5	Sundry Expenses	72	18	10			
87	2	5					88	15	8
29	11	1	„ Postages				33	13	9
174	2	9	„ Printing and Stationery				225	18	0
150	0	0	„ Secretary's Salary				150	0	0
426	10	9	„ Convention Expenses				609	15	11
18	9	9	„ Commission				24	10	0
11	15	0	„ Electric Vehicle Committee Expenses ...				1	11	2
65	7	8	„ Surplus				62	7	6
£962	19	5					£1,196	12	0

BALANCE SHEET as

1914 £	s.	d.	LIABILITIES.	£	s.	d.	1915. £	s.	d.
21	5	0	To Subscriptions paid in advance				19	19	0
9	3	3	„ Sundry Creditors				17	1	6
			„ Surplus—						
721	0	9	Balance, April 1st, 1914	786	8	5			
65	7	8	Plus Surplus, for year 1914-15 ...	62	7	6			
							848	15	11
786	8	5							
£816	16	8					£885	16	5

Report of the Auditors, to the Members of the Incorporated Municipal

We have audited the above Balance Sheet, dated 31st March, 1915, and cur opinion it is properly drawn up so as to exhibit a true and correct view of and the explanations given us, and as shown by the books of the Association.

140, Leadenhall Street, London, E.C., 19th April, 1915.

ELECTRICAL ASSOCIATION.

for the year ended 31st March, 1915.

months ended 31st March, 1914.

1914. £	s.	d.	INCOME.	£	s.	d.	£	1915. s.	d.
			By Annual Subscriptions—						
174	6	0	Committees	175	7	0			
187	19	0	Members	187	3	0			
4	4	0	Associate Members	4	4	0			
7	10	0	Associates	7	0	0			
373	19	0					373	14	0
19	15	8	„ Dividends and Interest				19	9	6
			„ "Proceedings"—						
106	5	0	Sales and Advertisements				139	9	9
462	19	9	„ Convention Receipts...				663	13	9
£962	19	5					£1,196	12	0

at 31st March, 1915.

1914. £	s.	d.	ASSETS.	£	s.	d.	£	1915. s.	d.
			By Sundry Debtors—						
–	–	–	Committees	1	1	0			
6	6	0	Members	11	11	0			
1	1	0	Associate Members	–	–	–			
1	10	0	Associates	2	0	0			
4	0	0	Sundry	0	15	0			
12	17	0		15	7	0			
6	7	0	Less Reserve for Bad Debts ..	1	6	0			
6	10	0					14	1	0
107	10	0	„ Parliamentary Expenses to be refunded ...				123	15	0
			„ Investment *at Cost*—						
599	5	0	£600 L.C.C. 3½ % Stock				599	5	0
–	–	–	£105 19*s.* 9*d.* 3½% War Loan Stock ...				100	0	0
			NOTE.—The present market value of these investments is £635 10 0.						
			„ Cash—						
103	11	8	At Bank				42	18	8
–	–	–	In Hand				5	16	9
£816	16	8					£885	16	5

Electrical Association.
have obtained all the information and explanations we have required. In the state of the Association's affairs, according to the best of our information

BOLTON, PITT & BREDEN, *Auditors.*
J. E. EDGCOME, *Hon. Treasurer.*

REPORT OF THE DEVELOPMENT COMMITTEE.

There have, to date, been five Meetings of the Development Committee.

The full membership at the present time is as follows :

I.M.E.A. MEMBERS.

S. E. Fedden, Sheffield (Chairman) ; S. T. Allen, Wolverhampton ; F. Ayton, Ipswich ; A. S. Blackman, Sunderland ; C. McArthur Butler (Secretary, I.M.E.A.) ; R. A. Chattock, Birmingham ; A. C. Cramb, Croydon ; Councillor Crowther, Sheffield ; J. E. Edgcome, Kingston-upon-Thames ; Alderman Ellaway, Birmingham ; F. M. Long, Norwich ; H. Faraday Proctor, Bristol ; H. Richardson, Dundee ; T. Roles, Bradford ; Alderman Pearson, Bristol ; A. H. Seabrook, Marylebone ; Alderman Smith, Barrow-in-Furness ; W. A. Vignoles, Grimsby ; G. Wilkinson, Harrogate ; J. W. Beauchamp, West Ham (Acting Hon. Secretary, Development Committee).

CO-OPTED MEMBERS.

Associated Municipal Electrical Engineers (Greater London), W. C. P. Tapper ; British Electrical Federation, W. L. Madgen ; Cable Makers' Association, L. B. Atkinson ; Association of Electrical Power Companies, W. A. Chamen, A. de Turckheim ; Electrical Contractors' Association, L. G. Tate ; British Electrical and Allied Manufacturers' Association, D. N. Dunlop, A. J. Ireland, G. Maurice, H. C. Siddeley ; Society for Electrical Development (America), F. W. Willcox.

Present Method of Working.

Meetings.—Meetings of the Development Committee were held monthly up to the 16th of April, 1915, when it was decided that, owing to the difficulties in carrying out this class of work, brought about by the war, and the increased demand upon the time of members, that the meetings should

only take place approximately once in three months; the Chairman having power to call a Special Meeting at a shorter interval if required.

Reports of each Meeting of the Committee are submitted to the Council of the I.M.E.A. for confirmation before action is taken.

A brief statement concerning the work carried out by the Committee is communicated to the electrical press from time to time.

Ways and Means.—So far, no special arrangements have been made for providing funds for carrying on the work of the Committee; the out-of-pocket expenses in connection with the Secretarial work having been defrayed by the funds of the I.M.E.A.

Division of Sub-Committees.—It was decided that the actual work of the Committee should, so far as possible, be broken up and given out to Sub-Committees of comparatively limited size and scope of operations; such Sub-Committees to be distributed geographically so far as convenient.

In the first instance the following Sub-Committees were constituted and put in motion:

(1) Publicity Sub-Committee. (London District.)
I.M.E.A. Members.—A. H. Seabrook, A. C. Cramb (Hon. Secretary).
Co-opted Members.—D. N. Dunlop, C. Palmer, W. C. P. Tapper, L. G. Tate, F. W. Willcox.

(2) Electrical Installations Sub-Committee. (Bradford District.)
I.M.E.A. Member.—T. Roles (Hon. Secretary).

(3) Domestic Appliances Sub-Committee. (Birmingham District).
I.M.E.A. Members.—R. A. Chattock, G. Wilkinson, S. T. Allen (Hon. Secretary).
Co-opted Members.—C. M. Shaw, T. P. Wilmshurst.

The Secretaries of the various Sub-Committees report to the Development Committee from time to time on the progress of their work.

The Development Committee resolved that the Sub-Committees should have the power to co-opt persons who might, by reason of their work or experience, be useful to the Committees in connection with any particular work or investigations which they have in hand.

Up to date the principal work which the Sub-Committees have been engaged in has been as follows :

(1) Publicity Sub-Committee.—The preparation, in preliminary stages, of a scheme of co-operative advertising, printing, and publicity work.

The Sub-Committee have interviewed advertising agents and printing firms, and obtained information with regard to the possibilities of producing publicity matter, and for bringing about an arrangement with a suitable firm for the production of such matter under the guidance of the Publicity Committee, and for the payment towards the funds of the Development Committee of some proportion of the profits which might accrue in the sale of such matter to electricity undertakings.

Mr. Dunlop, on behalf of the B.E.A.M.A., offered office accommodation, and the assistance of himself and his staff, to further these objects particularly in regard to detailed work of purchasing, distributing and collecting accounts in regard to the publicity matter. This offer has been accepted by the Development Committee, who hereby express their appreciation of the same, and hope that the future may enable them to avail themselves of it at least until such time as reasonable funds are forthcoming, and the Development work of the I.M.E.A. can be put upon a proper financial basis.

The Publicity Sub-Committee have, after due deliberation, insisted upon the absolute necessity of providing regular funds and the establishment of at least a small paid staff whose whole time could be devoted to this class of work, leaving the members only the task of guiding and making suggestions with regard to the class and suitability of the matter to be prepared, in fact the general direction of the Publicity Campaign.

The Sub-Committee direct attention to the urgent need of the provisions relating to publicity work which are contained in the I.M.E.A. Bill, and feel that their operations must be heavily handicapped until fuller powers are granted to Municipal Electric Supply Undertakings.

Communication has been opened up with the Publicity Committee of the London Electric Supply Companies with a view, if possible, to combining the efforts of all classes of electric supply undertakings in regard to publicity, to avoid wasteful overlapping and bring about at the earliest moment an organised campaign for the development of public electricity service. At the present time the Sub-Committee are not in a position to report progress in this direction.

Communications have also been received and considered from the Society for Electrical Development, New York, the Manager of which (Mr. Wakeman) was good enough to offer assistance, and so far as possible, means of co-operation between publicity undertakings on both sides of the water, and it is hoped that under circumstances more favourable to this class of work than those at present obtaining, that this idea may be developed.

(2) Electrical Installations Sub-Committee.—In this case, operations have been very much interfered with by the present abnormal conditions, but the Secretary has reported upon the preliminary stages taken to bring together suitable men for procedure with this work as soon as possible.

For the present the Electrical Installations Sub-Committee will proceed so far as possible :

(*a*) To examine, tabulate, and describe the various methods of wiring in use, with advantages and disadvantages, with a view to bringing about any possible reductions in the cost of installation work compatible with safety.

(*b*) To obtain the assistance and opinions of practical men in touch with this class of work, and to promote discussion on the subject.

(*c*) To promote practical criticisms of accessories in common use, in connection with installation work, with a view to collating information which would be valuable to manufacturers and users.

(*d*) To take an early opportunity of considering alternatives to the present design of plug contact for heating, cooking, and other purposes, particularly in regard to the possibilities of superseding the ordinary pin or concentric patterns by some more satisfactory form of plug contact.

(3) Domestic Appliances Sub-Committee.—Here again also, considerable difficulty has been experienced owing to the war.

The Secretary has reported preliminary work done and plans for the immediate future ; the proposition being to carry out various investigations with regard to Hot and Boiling Plates, and to invite the advice and criticisms of Manufacturers in connection with that subject.

The Sub-Committee's work will be devoted more particularly to points arising in connection with electrical apparatus primarily intended for domestic use, although also usable for business and other purposes. The scope of the Committee's work will cover the whole of the apparatus from its connection with the permanent wiring of the installation, that is to say, from where the work of the Electrical Installations Sub-Committee would leave off.

It is suggested that the Sub-Committee shall also collect and analyse information with regard to Domestic Electrical Appliances, their advantages, cost, etc., and that from

Engineers and Users opinions should be sought, and all such information tabulated with a view to making it readily available to the whole of the Committee.

It has been further suggested that such results, after collection and suitable analysis, might be produced in booklet form, and, when confirmed by the Council, they could be sold, and would presumably contain matter of use and interest to manufacturers and others. Also, any information obtained in this way would constitute valuable guidance for the Publicity Sub-Committee. Later, it is hoped to expand into the questions of Hire and Hire Purchase ; Costs of maintenance of apparatus ; and analysis of existing schemes.

National Proving House.—" The Development Committee considered a letter published in the technical press, from Mr. C. H. Wordingham to the Secretary of the I.E.E., dealing with the question of establishing a Central Testing Institution or Proving House. The Committee associated itself with the views expressed by Mr. Wordingham therein, but urged that the National Physical Laboratory and its existing organisation should be employed whenever possible, as further support would enable it to extend its field of operations and would have the advantage of assisting to develop a Laboratory which is entirely independent of trade interests."

Standardisation of Apparatus.—This question has received the attention of the Committee, who have kept in mind the desirability of assisting manufacturers to produce cheaper appliances ; also the danger of crystalising design in regard to appliances which appear capable of considerable further development. It is proposed in this connection to work as far as possible in conjunction with the Engineering Standards Committee.

General.—From time to time, the Development Committee has had under consideration the general questions arising out of the I.M.E.A. Bill. The restriction of borrowing facilities, and the difficulties arising in connection with the operation of electricity works under the present conditions, and in view of the shortage of labour. In most cases reports have been made from the point of view of the Development Committee to the Incorporated Municipal Electrical Association Council, which body has given the matter further consideration as required.

REPORT OF THE ELECTRIC VEHICLE COMMITTEE.

The following has been the constitution of the Committee between the 1st April, 1914, and the 31st March, 1915, the period covered by the Report :

Representing the Incorporated Municipal Electrical Association—
F. Ayton, Engineer and Manager, Ipswich Corporation Electric Supply and Tramways.
J. W. Beauchamp, Engineer and Manager, West Ham Corporation Electric Supply.
R. A. Chattock, City Electrical Engineer, Birmingham.
J. Christie, Engineer and Manager, Brighton Corporation Electric Supply.
A. C. Cramb, Borough Electrical Engineer, Croydon.
J. E. Edgcome, Borough Electrical Engineer, Kingston-upon-Thames.
H. Faraday Proctor, Engineer and General Manager, Electricity Department, City of Bristol, Hon. Sec. I.M.E.A.
A. H. Seabrook, Manager, St. Marylebone Electric Supply.

Representing Commercial Motor Users' Association, Incorporated—
E. S. Shrapnell-Smith, Editor of " The Commercial Motor."

Representing Provincial Electric Supply Companies—
F. E. Gripper, Managing Director, Edmundson's Electricity Corporation, Ltd., London.

Representing Electrical Contractors' Association—
W. R. Rawlings, Rawlings Bros., Ltd., London.

Representing British Electrical and Allied Manufacturers' Association—
R. A. R. Bolton, Siemens Bros. Dynamo Works Co., Ltd.
E. S. Jacob, Tudor Accumulator Co., Ltd.
W. S. Naylor, Chloride Electrical Storage Co., Ltd.
A. R. Everest, British Thomson-Houston Co., Ltd.

Representing Incorporated Association of Electric Power Companies—
J. S. Highfield, Chief Engineer, Metropolitan Electric Supply Co.

Representing Makers of Electric Vehicles—
K. Bowen, " Cedes " Electric Traction, Ltd.
E. W. Curtis, Managing Director, General Vehicle Co., London.
Conway Jenkins, Fram Electric Vehicles.
J. F. Monnot, Arrol-Johnston, Ltd.
P. A. Mossay, Lloyd Electric Cars.

Representing Edison Accumulators, Ltd., London—W. H. L. Watson.

Representing the British Electrical Federation, Ltd.—R. J. Howley.

Representing the Chelsea Electricity Supply Co., Ltd.—P. Still.

Ten meetings of the Committee have been held, all in London with the exception of that which was held in Birmingham in May.

The Committee elected the following as its Officers for the year :

Chairman, R. A. Chattock.
Hon. Secretary, F. Ayton.
Hon. Treasurer, J. Christie.
Chairman of the Technical Sub-Committee, R. A. Chattock.
Acting Hon. Secretary of the Technical Sub-Committee, J. Christie.
Chairman of Commercial Sub-Committee, A. H. Seabrook.
Hon. Editor of *The Electric Vehicle*, A. H. Seabrook.

The Secretary of the Association, Mr. McArthur Butler, attends the meetings officially on behalf of the Association, and the Committee are indebted to him for much valuable assistance.

The work of the Committee during the period mentioned has covered the following :

Charging Plug and Receptacle.—The method to employ in gripping the charging cable to the plug was decided upon, and a complete design and specification for the plug and receptacle was published in the March issue of *The Electric Vehicle*. An application was submitted to the Engineering Standards Committee for the standardisation of this accessory, and the Sub-Committee of that body, which dealt with the matter, agreed to recommend the

Committee to standardise the dimensions of the contacts, as well as to supervise the manufacture of gauges for them. Two firms in this country are now supplying the fitting in accordance with this Committee's Specification.

Tariff for Electric Energy for Charging Vehicle Batteries.—The Committee attach great importance to the adoption, as far as possible, of a uniform tariff throughout the country for this purpose. They have, in various communications addressed to electric supply undertakings, urged them to come into line upon a flat rate of 1d. per unit for "off peak" supply. The list published in the March number of *The Electric Vehicle* contains the names of 105 Undertakings that have adopted the Committee's recommendation on this matter. The Committee believe it is only a question of time before all progressive undertakings will adopt this tariff.

Financial Support.—When the Committee got fully to work, it was soon apparent that funds were necessary in order to make real progress. Up to that time what little expenditure had been necessary was borne by the parent Association. It was, therefore, decided to appeal to all electric supply undertakings for financial support, and the accounts show that the response has, on the whole, been satisfactory. The Committee are under a special debt of gratitude to Alderman J. P. Smith of Barrow, who started the list with a private donation of £5, and to the Accumulator Makers' Section of the British Electrical and Allied Manufacturers Association, who came forward with a handsome contribution of £50. In a few instances Corporations have announced that they will make the contribution an annual one, and the Committee sincerely trust that all the donors mentioned in the accompanying list will give similar amounts during the present year. The important work which the Committee is engaged upon cannot go forward without adequate financial support.

LIST OF SUBSCRIPTIONS RECEIVED UP TO 31ST MARCH, 1915.

	£	s.	d.
Miscellaneous :			
Alderman J. P. Smith, Barrow	5	0	0
Proprietors of *The Commercial Motor*	5	5	0
The British Insulated and Helsby Cables Co.	5	5	0
The British Electrical and Allied Manufacturers Association	50	0	0
Associated Municipal Electrical Engineers of Greater London	2	2	0
Edison Accumulators, Limited	10	0	0
Mossay & Co.	5	0	0
Corporations :			
Barnsley	2	2	0
Chester	2	2	0
Grimsby	2	2	0
Sheffield	3	3	0
Croydon	3	3	0
Birmingham	3	3	0
Birkenhead	3	3	0
Bootle	2	2	0
Glasgow	3	3	0
Exeter	1	1	0
Ipswich	2	2	0
Eastbourne	1	1	0
West Ham	3	3	0
Bridlington	1	1	0
Eccles	2	2	0
Liverpool	3	3	0
Edinburgh	3	3	0
Dewsbury	2	2	0
Bradford	3	3	0
Dundee	3	3	0
Stoke-on-Trent	2	2	0
Tynemouth	2	2	0
Loughborough	1	1	0
Lincoln	2	2	0
Newport	2	2	0
Derby	3	3	0
Coventry	3	3	0
Bury	2	2	0
Hull	3	3	0
Worthing	1	1	0
Brighton	3	3	0
Rotherham	2	2	0
South Shields	2	2	0
Blackpool	2	2	0
Burton-on-Trent	2	2	0
Manchester	3	3	0
Bristol	2	2	0
Halifax	3	3	0
Darlington	2	2	0
St. Helens	2	2	0
Carried forward	£178	3	0

	£	s.	d.
Brought forward - - - - -	178	3	0
Borough Councils :			
Poplar - - - - - - - -	3	3	0
Battersea - - - - - - - -	2	2	0
Urban District Councils :			
Beckenham - - - - - - -	1	1	0
Dundalk - - - - - - - -	1	1	0
St. Annes-on-the-Sea - - - - - -	1	1	0
Total - - -	£186	11	0

STANDARD CHARGING VOLTAGE.—After considering the matter, the Committee decided that it would be of advantage to adopt a definite range of charging voltage. They consequently fixed this range between 85 and 120, which corresponds with the voltage which will take care of the charging of forty-four lead plate cells, or the equivalent of sixty Nickel-iron-alkali cells.

STANDARD NUMBER OF CELLS.—For the reason given above, the Committee have fixed forty-four as the standard number of cells per vehicle for lead plate batteries.

SIGNS FOR CHARGING STATIONS AND GARAGES.—The Committee have standardised a design for both the illuminated and enamel plate types, and have appointed Official Makers for each type. Full particulars have been published in the Journal.

JOURNAL.—To serve as a means of bringing before possible users the advantages of the electric vehicle, the Committee decided to publish a Quarterly Journal, to which they gave the name of *The Electric Vehicle*. After inviting offers from various publishing firms, they decided to appoint, as their Official Publishers for the Journal and General Publicity Matter, The Electrical Press, Ltd., of 13, Fisher Street, Kingsway, London, W.C. The first number of the Journal was edited by the Honorary Secretary, and made its appearance in December, 1914. As the Honorary Secretary had only undertaken the bringing out of the first number, the ordinary duties of his office already absorbing a considerable amount of time, the Committee appointed as the Honorary

Editor Mr. A. H. Seabrook, who had kindly offered his services in this connection. The second number of the Journal was brought out in March, and it will appear quarterly. At the present time, 4,000 copies are published of each issue, and a large portion of this number is mailed free to Corporation Officials, Chairmen of Committees, Railway Managers, Engineers, and others who are interested in transportation generally. It was hoped that Corporation Electric Supply undertakings would purchase quantities for distribution among likely users in their territories, but so far only a limited number of undertakings have made use of this potent means of building up a most remunerative business. The Committee venture to hope that, in future, the number of undertakings making use of the Journal in this respect will materially increase.

Publicity Matter.—As a further means of drawing attention to the merits of the electric vehicle, the Committee designed and published a series of twelve publicity Mail Cards intended to be sent, at intervals, to possible users by Electricity Supply undertakings. Four thousand copies of each of the twelve cards were printed, but it is with regret that the Committee have to announce that, so far, there has been only a very small demand for these cards. The price at which they are sold is a very reasonable one, being 21s. for No. 1 set of 600 (50 of each card), and 42s. for No. 2 set comprising 1,200, or 100 of each card.

Standard Wheel Rims.—At the instance of the Society of Motor Manufacturers and Traders, the Engineering Standards Committee decided to standardise certain rims for solid rubber tyres, and your Committee decided to support the Association in this important matter by recommending that these rims, of the sizes given below, should be used for all commercial electric vehicles.

Sizes referred to are as follows :

670 mm.	741 mm.	850 mm.
720 mm.	771 mm.	881 mm.

Glow Lamps for use on Electric Vehicles.—It was suggested to the Committee by the Tungsten Lamp Association that there would be an advantage in standardising Metal Filament Glow Lamps for use on electric vehicles. In this view your Committee concurred, and, as a result, joint meetings were held with representatives from the Tungsten Lamp Association, and, with the approval of those representatives, the Committee advise that lamps of the size and voltage as recommended by the Engineering Standards Committee in their Report No. 69, be adopted as standard for electric vehicles, and that, in view of the small consumption and the comparatively short hours of use to which such lamps are put, that they be for the present coupled across a number of cells in the vehicle to give the required voltage, *i.e.*, 12 volts.

Measuring Instruments on Vehicles.—It seemed to the Committee desirable that they should express some opinion as to measuring instruments which it was advisable to provide on electric vehicles, and they, accordingly, expressed their views in this matter as follows : For vehicles provided with lead plate batteries, the use of a volt and ampere meter is recommended for controlling the charge and discharge. Where, however, it is not proposed to remove the battery from the vehicle, and where no constant attendance is provided during charging, they recommend that an ampere-hour meter should be provided in addition to the ammeter for showing the condition of the battery ; and they further recommend that suitable provision should be made in connection with the ampere-hour meter for automatically opening the circuit when the battery is fully charged. A mileage recorder is considered a necessary accessory, not only for gauging the condition of the battery in conjunction with the electrical instruments, but for keeping a record of the performance of the vehicle, and its efficiency.

In the case of vehicles fitted with Nickel-iron-alkali Batteries, an ampere-hour meter is the only instrument which need be provided, other than the mileage recorder.

Alarm Signals on Vehicles.—The Committee have considered the requirements in this direction, and they have recommended that a horn, preferably of the electrically operated type, is the most suitable.

Co-operation between the Committee and the Commercial Motor Users' Association.—Through the good offices of a member of the Committee, Mr. E. S. Shrapnell-Smith, who is the representative of the Commercial Motor Users' Association, it has been arranged that the Association will allow the Committee a voice in all future arrangements which they make in regard to Parades of Motor Vehicles in so far as such arrangements apply to electric vehicles. The Association has also very kindly offered to allocate to the use of this Committee a section in the next edition of its "Night Shelter Handbook for Commercial Vehicles," in which the Committee can set forth information as to Charging Stations about the country, Tariffs, etc., and the Association has also offered to include a Map upon which these Charging Stations may be indicated. The Committee take this opportunity of recording their thanks to Mr. Shrapnell-Smith, and the Association he represents, for their kindly courtesy in these matters.

Affiliation with the Electric Vehicle Association of America.—The Committee desire to again refer to the most useful results which have followed upon the continued affiliation with this important Association through the membership of their Honorary Secretary. The Association, both through its most energetic Executive Secretary, Mr. A. Jackson Marshall, and the Chairmen of its various Committees, has shown itself most anxious to help this Committee whenever such help has been asked. The Committee desire to place upon record their appreciation of the value of this co-operation, and their thanks for much useful information received.

Standard Charging Equipment and Methods of Charging.—The importance of this subject has been

recognised by the Committee, and, for some time, the Technical Sub-Committee have been hard at work upon it. A very full report is in hand, which the Committee hope to publish shortly.

AUDITOR'S REPORT.—The audited Statement of Accounts and Balance Sheet is attached to this Report.

While this Report mentions the special matters dealt with by the Committee, it does not detail the many other directions in which the Committee has been active in stimulating interest in the electric vehicle, and making efforts to promote its adoption. Enquiries are constantly being received for information on one matter or another, so that the secretarial detail work has been somewhat heavy, the Secretary's outward letters, exclusive of ordinary acknowledgments, circular letters, receipts, etc., numbering 1,140 during the period under review.

In closing this Report, the I.M.E.A. representatives on the Committee take the opportunity of expressing their thanks to the co-opted members for the extremely valuable work which they have so willingly performed during the year under review. It is no exaggeration to say that the progress which has been made would have been impossible but for the assistance which these gentlemen have given.

INCORPORATED MUNICIPAL

THE ELECTRIC

INCOME AND EXPENDITURE ACCOUNT

EXPENDITURE.

	£	s.	d.	£	s.	d.
To Postages and Telegrams				47	6	2
,, Printing and Stationery				31	1	7
,, Sundry Expenses				12	3	0
,, Clerical Assistance				21	9	5
,, Printing Mail Cards and Journal (Nos. 1 and 2)	167	4	11			
,, *Less* Stock of Publicity Mail Cards, value taken at half Sale Price	30	0	0	137	4	11
				249	5	1
,, Surplus				95	5	3
				£344	10	4

BALANCE

LIABILITIES.

	£	s.	d.
To Sundry Creditors	16	16	8
,, Surplus, as per Income and Expenditure Account annexed	95	5	3
	£112	1	11

REPORT OF THE AUDITORS TO THE MEMBERS

We have audited the above Balance Sheet, dated 31st March, 1915, and our opinion it is properly drawn up so as to exhibit a true and correct view tion and the explanations given us, and as shown by the books of the

140, Leadenhall Street, London, E.C.
5th May, 1915.

ELECTRICAL ASSOCIATION.

VEHICLE COMMITTEE

for the year ended 31st March, 1915.

INCOME.

	£	s.	d.	£	s.	d.
By Subscriptions :						
Municipalities	116	11	0			
Other Associations	52	2	0			
Companies and Private Individuals	30	10	0			
				199	3	0
„ Journal (Nos. 1 and 2) and Mail Cards—Sales and Advertisements				145	7	4
				£344	10	4

SHEET.

ASSETS.

	£	s.	d.	£	s.	d.
By Sundry Debtors :						
Municipalities	12	12	0			
Electrical Press, Ltd.	9	15	5			
				22	7	5
„ Sample Apparatus	..		..	1	8	7
„ Furniture	..		..	7	10	0
„ Stock of Publicity Mail Cards, value taken at half Sale Price ..				30	0	0
„ Cash :	£	s.	d.			
At Bank	46	11	5			
In hands of Secretary	4	4	6			
				50	15	11
				£112	1	11

On behalf of the Committee,

F. AYTON, *Hon. Secretary.*

J. CHRISTIE, *Hon. Treasurer.*

OF THE ELECTRIC VEHICLE COMMITTEE.

have obtained all the information and explanations we have required. In
of the state of the Committee's affairs according to the best of our informa-
Committee.

BOLTON, PITT & BREDEN, *Auditors.*

Annual General Meeting.

The Twentieth Annual General Meeting was held at the Institution of Electrical Engineers on Friday, June 18th, 1915, at 10 a.m. Mr. A. C. Cramb, Acting-President, presided.

The Annual Report having been previously circulated to the members, was taken as read.

Engineering Standards Committee.—**Mr. R. A. Chattock** (Past President) called attention to the reference in the Report to the Engineering Standards Committee. A considerable number of members of the Association were representatives on that Committee and were in personal touch with the work that was being done. The Council wished to impress upon the members of the Association and especially the Committee Members, the extreme importance of this work and the large saving which it effected in the work of municipal electric supply departments. The standard specifications for various sections of electrical plant which had been issued by the Standards Committee were of great assistance to municipal electric supply engineers and saved an enormous amount of work in the preparation of their own specifications. For this reason the Council felt that it was justified in voting a sum of twenty guineas to the funds of the Standards Committee. He wished to strongly support the appeal now being made to Electric Supply Committees to contribute liberally to the funds of the Standards Committee and to make their contributions in the form of annual subscriptions.

Loan Sanctions during the War.—**Mr. H. Faraday Proctor** (Hon. Secretary) referring to this matter said he had a letter from Sir John Snell, who, together with Mr. Sparks, President-elect of the Institution of Electrical Engineers, Sir John Woolfe Barry, President of the Institution of Civil Engineers, and Sir Alexander Kennedy, on behalf of the Institution of Mechanical Engineers, was forming a deputation to wait upon

the Treasury with reference to municipal loans. No definite arrangements had been made up to the present, but the Institutions in question were showing sympathy towards Municipalities, and he wished to assure the members of the Association that their interests were being very well looked after wherever these interests coincided with our interests in the furtherance of the war. The members of the Association had been circularised with regard to the matter, and inquiries were made as to what Municipalities wanted loans and the purposes of the loans. He himself went very carefully through all these, and the important cases were referred to Sir John Snell, who had taken, or was taking, this matter up with the Government Departments.

Councillor Barge (Poplar) moved, and **Mr. E. S. Raynor** (Doncaster) seconded the adoption of the report, which was carried unanimously.

Balance Sheet.—**The Chairman** stated that unfortunately the Hon. Treasurer, Mr. J. E. Edgcome was too unwell to be present and therefore the meeting would not have the privilege of personal statement from him on the balance sheet. The only important matter, he thought, was the investment of £105 19s. 9d. in 3½ per cent. War Stock. He moved the adoption of the balance sheet.

Bailie Nairn seconded, and the proposal was carried unanimously.

Re-election of Auditors.—Messrs. Bolton, Pitt & Breden were unanimously re-elected auditors.

Report of the Development Committee.—**Mr. S. E. Fedden** (Past President) as Chairman of this Committee, introduced the report for the past year. He said that the Committee had tried to organise the matters coming within its scope, but the war had naturally very much interfered with that organisation because the Sub-Committees, which had been formed, had been too busy to do much in the matter of co-opting members and getting to work on the departmental work which had been given to them. It had been decided to cut the work up into districts for different parts of the country and to co-opt persons who were

not members of the Association, but who would be useful to these Sub-Committees. It had been suggested that the present time was not really opportune to carry on such publicity work, but after very carefully considering the matter, it had been decided that whilst the Committee was not going on with its work in an energetic manner it would keep it alive, and if possible, get the first organisation finished and try to do some advertising if it could be done without any heavy expense. He moved the adoption of the report.

Alderman J. P. Smith (Barrow-in-Furness) seconded the resolution, which was carried unanimously.

The Electric Vehicle Committee.—**Mr. R. A. Chattock** (Past President and Chairman of the Committee) moved the adoption of this Report and, in doing so, said he wished to call attention to the large amount of work that had been done during the past twelve months, especially in connection with the standardising of apparatus to be used with the vehicles, such as the charging plug and receptacle, and the size of the plates in the battery so that they could be made interchangeable as far as possible. Much had also been done in relation to the charging arrangements and switchboards, which should also be standardised as far as possible, and the recommendation of the Committee on these points would be published in the next issue of the *Electric Vehicle*. He hoped that the members of the Association would support the Committee by taking issues of the Journal. It came out once a quarter, and so far three numbers had been issued. He was pleased to say that the last issue had gone off very much better than the previous ones, and it seemed as if the efforts of the Committee in that direction were being appreciated. The publicity matter that was being issued should be very valuable in the various towns for stimulating the interest of the public in these vehicles. The parade on the previous day was very much appreciated by those members of the Association who witnessed it, and it also seemed to create considerable interest in the general public ; such a parade should do a great deal to stimulate the use of these vehicles in the country generally. He hoped that these demonstrations would be possible later on in the large towns, and in that way the industrial undertakings throughout the country could see at their doors the great advantage of using these vehicles. He did not like to be always asking for contributions, but in connection with the very satisfactory response that had already been made to the funds of the

Committee, he would like to ask consideration in one direction. A great many towns had contributed to the funds of the Committee, and for those contributions it was very thankful, but what he wished to ask was, that these contributions should be, if possible, made annual ones, so that the Committee could rely upon carrying on the work already being done, and upon having proper financial support for doing so. From the balance sheet it would be seen that the funds had been properly and satisfactorily dealt with.

Mr. S. J. Watson (Member of Council) (Chief Electrical Engineer, Bury) seconded the adoption of the report of the Committee, and in doing so emphasised the splendid work which had been accomplished by Mr. Ayton, the Hon. Secretary. The Members of the Council appreciated the work done by Mr. Ayton, and he thought that the general body of members would also like to express their thanks. Mr. Ayton was a very busy man in his own town but had nevertheless given a tremendous amount of time to the matter and they all felt under a great debt of obligation to him.

The Chairman said he would like to support the remarks made with regard to Mr. Ayton's work on this Committee. The work of any committee was in the main due to the secretary, but as a member of the Electric Vehicle Committee he had great admiration for the energy and persistence with which Mr. Ayton had followed up the work.

The report was adopted.

Election of Officers and Council.—Mr. J. Christie (Brighton) and Bailie Stevenson (Edinburgh) were appointed by the meeting as Scrutineers of the ballot. The Chairman having pointed out that there had been no additional nominations for any of the following offices, declared those nominated to be duly elected, as follows:

President.
A. C. Cramb, Croydon.

Senior Vice-President.
F. M. Long, Norwich.

Junior Vice-President.
A. H. Seabrook,
St. Marylebone.

Hon. Solicitor.
Alderman G. Pearson, Bristol.

Hon. Secretary.
H. Faraday Proctor, Bristol.

Hon. Treasurer.
J. E. Edgcome, Kingston-upon-Thames.

The following were the nominations for vacancies on the Council :

Engineers, eight candidates for three vacancies :

S. T. Allen, Wolverhampton.
Walter J. Bache, Cheltenham.
S. E. Britton, Chester.
W. H. Cooke, Luton.
C. S. Davidson, Mortlake.
W. W. Lackie, Glasgow.
S. L. Pearce, Manchester.
J. A. Robertson, Salford.

Committee Representatives, four candidates for two vacancies :

Councillor H. R. Barge, Poplar.
Alderman Sir J. Beecham, St. Helens.
Alderman H. W. Littler, West Ham.
Alderman Duncan Watson, St. Marylebone.

On the report of the Scrutineers being received the Chairman announced the result of the ballot to be as follows :

ELECTED :

Engineers :

S. E. Britton, Chester.
W. W. Lackie, Glasgow.
S. L. Pearce, Manchester.

Committee Representatives :

Councillor H. R. Barge, Poplar.
Alderman Sir J. Beecham, St. Helens.

PLACE OF MEETING FOR 1916.—**The Chairman** suggested that under the circumstances caused by the War, it would be advisable to leave this matter in the hands of the Council.

Alderman Smith (Liverpool) thought that no harm would be done in fixing a place for meeting in 1916. Incidentally he complained that it was a waste of time to read papers in full at these meetings ; those distributed before the meeting should be taken as read, so that the whole time of the meetings could be given up to discussions and replies. This would enable representatives present to give utterance to at least one thought.

The Chairman said that the Council would take this suggestion into consideration.

Mr. H. Faraday Proctor (Hon. Secretary) proposed that the place of meeting for 1916 be left in the hands of the President and Council. Personally he would like the meeting held at some other place than London. There the members seemed to get very scattered and there were not those opportunities for informally meeting together which was so useful a feature of the provincial gatherings.

The proposition having been seconded was put to the meeting and carried.

Other Business.

Insurance against Aircraft Damage.—**Mr. H. Faraday Proctor** (Hon. Secretary) read a letter from Mr. J. E. Edgcome, the Hon. Treasurer, asking the Association to pass a resolution urging the Government to pledge itself to bear the cost of damage to property from hostile aircraft. It was suggested that it should not be necessary for owners to insure their property against such destruction. This matter had been considered by the Council who were in sympathy with the views expressed by Mr. Edgcome, and, on behalf of the Council, he proposed the following resolution:

> "That this Meeting is of opinion that the Government should hold themselves financially responsible for all damage to real and personal property situated in the British Isles, directly attributable to the present war."

At the present time the Government, he believed, held themselves responsible for damage to real property, but although they would recompense a man for damage to his house they would not recompense the tenant for damage to furniture inside that house, and it was felt to be very hard on people suffering damage to their private property not to receive recompense. He suggested that this resolution should be carried, and that a copy should be transmitted to the Prime Minister.

Mr. F. Ayton (Ipswich) seconded. In his town, he said they were very much interested in this question, and felt very strongly that the rates of insurance on the East Coast were too heavy, and that the risk should be distributed over the country

Councillor Crowther (Sheffield), supported the resolution. Some parts of the country he said, were much more in danger

from air raids than others and he did not consider it fair that they should bear their own risks. Many parts of the country liable to air raids were engaged in the manufacture of munitions of war and any damage they sustained from air raids should be a national charge.

Alderman Smith (Liverpool), said that the sentimental view of Councillor Crowther did not commend itself to him. The heavy burden that the nation had to bear was being added to continuously. Men who were making munitions were also making profits, and the proper course was not to pass such a sweeping resolution. It would be much better for those who desired to be insured, to be insured by the Government at a nominal or reasonable premium.

Councillor Jones (Kilmarnock), thought they should do all that was possible to strengthen the hands of the Government in the present circumstances. Recently in the House of Commons it had been said that the Government were taking the responsibility and meeting the loss sustained by people in the country from air raids. Personally he did not agree with Alderman Smith. In this case they could not differentiate or distinguish. As a nation they were one community, and as a nation they should meet the loss sustained by individuals. He therefore supported the resolution.

The resolution was put to the meeting and carried unanimously.

Coal Supplies.—**The Chairman** said that there had been a national conference of the gas and electrical industries, and as Bailie Smith had been representing the I.M.E.A. in this matter, it would be interesting if he gave a brief account of what had transpired.

Bailie Smith (Member of Council, Glasgow), said after the very large meeting of the gas and electrical industries which had been held at the Institution of Electrical Engineers, it was generally known that a Committee had been formed to approach the Government. This was done about three weeks ago, and a dozen members had an interview with the Government Committee controlling the export of coal. It was found that that Committee was apparently a very strong one, and had the whole

thing at its fingers ends, and they could trust that Committee implicitly to keep a very tight grip on the question of letting coal go out of the country to neutral countries that were rather questionable. To our Allies that Committee would see that the coal was allowed to go out. About a week ago the Committee formed by the Conference was called to the Grand Committee Room at the House of Commons and met about 200 members of Parliament before whom they put the case, and a very good impression was made as to the necessity for some action. On Tuesday of that week a similar meeting was held wth those members of Parliament, and the result was that a committee of twelve had been formed to go into the matter and was to meet on the previous day, and it was hoped that within a week it would report to the Government and make some recommendations as to action. The six speakers representing gas and electricity industries were unanimous on two leading points. The first was the necessity of getting miners to work at least full time. In a report presented to the Government by a Committee formed a little while ago to enquire into the conditions in the coal mining industry it was admitted that there was avoidable absenteeism of from 4 to 12 per cent. In other words, whilst other people, engineers and all kinds of trades were working not only full time but overtime, the miners were not even working full time. It should be put to Parliament very strongly that they might use their influence to get the miners to work at least full time, and if all the miners in Britain worked full time, there would be not only coal to supply our own demands, but also the demands of our Allies. The second point was very well spoken to on the Tuesday afternoon by Sir Arthur Markham, Bart. Member for Mansfield, a colliery owner himself. He told members of Parliament that a fictitious and unreasonable price was being charged by some colliery owners for coal, and he recommended the Government to form some organisation that would control and fix the price of coal in each district, and at each colliery, based on the price of coal a year before the war plus the necessary increase in price, but not to allow colliery owners to change any speculative or fictitious price over and above that. He hoped the Government would adopt that view. Certainly just now it appeared to the Committee that the Government had got a move, and that they were going to do what they had been asked to do. He hoped that position would materialise and he urged all present to use their influence with their local members in order that members of Parliament might have the facts fully in their minds.

The Chairman said the statement was very satisfactory, and the Committee seemed to have done real work.

The Electrical Emergency Service.—**Mr. H. Faraday Proctor** (Honorary Secretary), said he had had some correspondence with Mr. Raphael of *Electrical Engineering*, but had only been able to bring the matter before the Council that morning. *Electrical Engineering*, as no doubt most of them were aware, had been energetic in taking up the question of the supply of switchboard attendants. There was a considerable shortage of these both in London stations and the provinces, as well as of other technical assistants. Mr. Raphael had felt for some considerable time past that men who were engaged on other work than at electricity works at the present time might take occasional shifts in electricity works as switchboard attendants, and he had registered the names of many such men, and had placed several of them in stations and sub-stations in London. Mr. Raphael, thought that with the support of this Association the matter might be taken up and the movement extended into the provinces. In many provincial centres no doubt that might be arranged. In centres situated in engineering districts there were many technical men with a certain amount of electrical knowledge, but in some other districts it would be very difficult to find men who would be competent to taken even the somewhat light duties of switchboard attendants, because, after all, it was necessary with them to have some little knowledge of electrical engineering. The Council did not propose that this matter should be thoroughly discussed that morning, because they felt that there were so many details in the arrangement that it would take up too much time. They therefore suggested that if it met with the approval of the members, it should be with the Council to make arrangements with Mr. Raphael, and if any of the members had any difficulty in getting temporary assistant or assistants during the war, they should apply either to the Council or direct to Mr. Raphael. He did not know how this matter would appeal to members, but would be glad to hear any comments in the meantime upon the proposal, avoiding as far as possible matters of detailed arrangements.

Councillor Barge (Poplar), moved that the whole matter be left to the Council as it would be quite impossible to discuss the necessary details that morning.

The Chairman said he did not think the details of this matter could be discussed and regarded the suggestion of Councillor Barge as the proper course. If any members wished to make use of the suggestion would they write either to Mr. Raphael, or to the Secretary if they required any assistance in the matter.

Votes of Thanks.—**Councillor Dymond** (Hereford), proposed a vote of thanks to Mr. A. C. Cramb for his work as Acting Chairman during the past year, and also for the manner in which he had presided at the meetings. The vote of thanks was put to the meeting and carried with acclamation. Votes of thanks were also accorded to the Honorary Officers.

The Chairman moved that a hearty vote of thanks be given to the President and Councillors of the Institution of Electrical Engineers for their courtesy in allowing the use of the Institution buildings for the meetings. This was carried unanimously. The proceedings then terminated.

MEMBERS AND DELEGATES ATTENDING THE LONDON MEETING, 1915.

Engineer Members as per Attendance Register.—R. L. Acland, Chesterfield ; S. T. Allen, Wolverhampton ; W. H. Allen, Loughborough ; H. W. Angus, Eccles ; N. Applebee, Ashton-under-Lyne ; C. C. Atchison, Rochdale ; F. Ayton, Ipswich ; R. Ayton, Winchester ; W. J. Bache, Cheltenham ; A. W. Barham, Watford ; J. W. Beauchamp, West Ham ; J. Bemrose, Leek ; W. C. Bexon, Kilmarnock ; A. Blackman, Sunderland ; A. W. Blake, Willesden ; H. Boot, London ; J. H. Bowden, Poplar ; S. E. Britton, Chester ; J. K. Brydges, Eastbourne ; H. R. Burnett, Barrow-in-Furness ; J. W. Burr, Swansea ; E. Calvert, Finchley ; R. H. Campion, Dewsbury ; R. A. Chattock, Birmingham ; J. Christie, Brighton ; S. Clegg, Lincoln ; J. H. Clothier, St. Annes-on-Sea ; W. H. Cooke, Luton ; F. H. Corson, Gloucester ; A. C. Cramb, Croydon ; E. Cross, Rotherham ; C. S. Davidson, Mortlake ; A. J. C. De Renzi, Newcastle-under-Lyne ; H. S. Ellis, South Shields ; F. Farndon, West Ham ; S. E. Fedden, Sheffield ; R. F. Ferguson, Hastings ; S. Cameron Gibson, Nuneaton ; T. Hall, Burton-on-Trent ; J. W. Hame, York ; E. E. Hoadley, Maidstone ; E. M. Hollingsworth, St. Helen's ; H. A. Howie, Walsall ; W. A. Jackson, West Bromwich ; S. D. Jones, Batley ; J. D. Knight, Ealing ; W. W. Lackie, Glasgow ; H. Tomlinson Lee, Wimbledon ; F. M. Long, Norwich ; R. V. Macrory, Londonderry ; F. V. L. Mathias, Warrington ; C. F. McInnes, Gravesend ; W. H. Miller, Fleetwood ; A. Nichols Moore, Newport, Mon. ; H. A. Nevill, Wakefield ; F. A. Newington, Edinburgh ; S. L. Pearce, Manchester ; J. D. Pember, Dartford ; R. W. L. Phillips, Bedford ; W. G. Pickvance, Wrexham ; H. Faraday Proctor, Bristol ; E. S. Rayner, Doncaster ; J. A. Robertson, Salford ; L. L. Robinson, Hackney ; W. M. Rogerson, Halifax ; T. Roles, Bradford ; A. H. Seabrook, St. Marylebone ; G. P. Shallcross, Birkenhead ; A. H. Shaw, Ilford ; C. M. Shaw, Worcester ; C. B. Smith, Hove ; T. R. Smith, Leicester ; N. Staniland, Hornsey ; H. Talbot, Nottingham ; J. E. Tapper, Beckenham ; W. C. P. Tapper, Stepney ; H. M. Taylor, Middlesbrough ; J. E. Teasdel, Pontypridd ; G. Tough, Coventry ; C. J. Turner, Hoylake ; W. A. Walker, Kettering ; S. J. Watson, Bury ; H. Webber, Keighley ; P. P. Wheelwright, Blackburn ; F. H. Whysall, Greenock ; G. Wilkinson, Harrogate ; H. Wilkinson, Radcliffe ; W. H. H.

Wood, Bolton ; L. W. Woodman, Dover ; C. H. Wordingham, London ; W. Wyld, Hampstead ; C. H. Yeaman, Stoke-on-Trent.

The following were delegated but did not sign the Register :— J. Boyce, Todmorden ; G. F. Craven, Reading ; H. Dickinson, Liverpool ; A. Ellis, Cardiff ; W. S. Foale, Portsmouth ; F. H. Lewis, Leytonstone ; R. Marshall, Ayr ; H. F. Street, Southampton ; F. Teague, Bath ; T. P. Wilmshurst, Derby.

Committee Members and Delegates as per Attendance Register :— Councillor W. J. Bailes, Liverpool ; Councillor H. R. Barge, Poplar ; Alderman Sir J. Beecham, St. Helens ; Councillor R. Bennett, Dartford ; Councillor J. E. Bestwick, Ilkeston ; Councillor G. W. Billington, Salford ; Councillor A. Blackman, Hastings ; G. H. Browne, Ilkeston ; W. Campbell Brown, Epsom ; Alderman A. A. Bumpus, Loughborough ; Councillor J. B. Burman, Birmingham ; Councillor J. Chrimes, Warrington ; Councillor D. J. Clarke, Birkenhead ; Councillor D. L. Connal, Greenock ; J. A. Crowther, Southampton ; Councillor J. W. Crowther, Sheffield ; Councillor G. W. Davis, Ilford ; H. H. Denton, Crewe ; Councillor E. R. Dymond, Hereford ; Alderman A. G. Ellaway, Birmingham ; Councillor C. T. Enwright, Bristol ; Councillor A. Fawcett, Halifax ; Alderman S. Flint, Leicester ; H. Foulds, Birmingham ; T. W. Fraser, Hoylake ; Alderman W. P. Gibbings, Carlisle ; Councillor R. Gibson, Wolverhampton ; Councillor W. F. Goodrich, Watford ; Councillor J. Haley, Bradford ; Bailie W. H. Hannay, Glasgow ; Councillor C. Higham, Blackburn ; Councillor J. Hoyle, Bradford ; Councillor W. Jamieson, Bury ; Alderman Jephcott, Birmingham ; D. Jones, Kilmarnock ; Councillor M. Jones, Pontypridd ; Councillor W. P. Jones, Bristol ; W. E. Kidner, Barking ; Councillor J. E. Kilburn, Dewsbury ; Alderman S. L. Kilpin, Bedford ; Councillor S. G. Kimber, Southampton ; Councillor J. H. King, Burton-on-Trent ; Councillor F. Lee, Coventry ; Alderman H. Leese, Stoke-on-Trent ; Councillor R. Leigh, St. Annes-on-Sea ; Councillor J. Lintott, Brighton ; Alderman H. W. Littler, West Ham ; Alderman S. Lloyd, Bristol ; Councillor J. H. Lofthouse, Harrogate ; Alderman T. Lyne, Kingston-upon-Thames ; Councillor D. McCallum, Greenock ; Councillor W. J. Merrett, Cheltenham ; Alderman S. W. Meyer, York ; Alderman D. B. Miller, Croydon ; Bailie J. M. Nairn, Dundee ; Councillor W. H. Payne, Hove ; Alderman G. Pearson, Bristol ; Alderman W. Pearson, Eccles ;

Alderman F. Phillips, Newport, Mon. ; Councillor J. O. Roberts, Gloucester ; Councillor T. Sauvage, Wrexham ; Councillor A. Sinclair, Swansea ; Alderman F. Smith, Liverpool ; Alderman J. P. Smith, Barrow-in-Furness ; Bailie W. B. Smith, Glasgow ; Councillor C. F. Spencer, Halifax ; D. Stenhouse, Glasgow ; Councillor A. Stevenson, Edinburgh ; Councillor P. Stirling, Doncaster ; Councillor A. Storrar, Chester ; H. Davey Turner, Willesden ; Alderman E. Vaughan, Maidstone ; Alderman C. West, Coventry ; Alderman H. J. Weston, Southampton ; Councillor H. Whitehead, Keighley ; Councillor A. E. Williams, Epsom ; J. Williams, Erith ; Alderman J. H. Wilson, Hornsey ; Councillor H. Womersley, Wakefield.

The following were delegated but did not sign the Register :— Councillor W. Allen, Radcliffe ; Councillor C. Atkinson, Fleetwood ; Councillor J. I. Bates, Coventry ; G. G. Bell, Hammersmith ; Councillor A. Brook, Todmorden ; Alderman G. H. Colwill, Swansea ; Alderman Sir J. Courtis, Cardiff ; Councillor W. H. Dawson, Plumstead ; Councillor H. Dyer, West Ham ; Alderman F. G. Foster, Portsmouth ; Councillor Fraser, Hampstead ; W. Frisby, Colchester ; A. J. Fuller, Fulham ; Alderman Goldsmith, Gravesend ; Councillor A. W. Golightly, Leytonstone ; Councillor D. Gordon, Barking ; Alderman H. T. Hatt, Bath ; C. Nelson Hefford, Leeds ; Councillor A. Hemingway, Portsmouth ; Councillor Dr. Joseph, Warrington ; Councillor Lupton, Leeds ; Councillor R. Moritz, Hornsey ; Alderman G. P. Morrish, Londonderry ; Councillor R. Pritchard, Liverpool ; Councillor E. Russell-Taylor, Liverpool ; Alderman Smithson, Leeds ; Councillor A. J. A. Stone, Cardiff ; Alderman Stuart, Wimbledon ; Councillor Umney, Croydon ; Alderman Wilkins, Derby ; Alderman Wilkinson, Luton ; Alderman D. L. Winter, Rotherham.

Several of the co-opted members of the Electric Vehicle Committee and of the Development Committee of the I.M.E.A. were also present, by invitation of the Council.

Incorporated Municipal Electrical Association.

FOUNDED 1895. INCORPORATED 1901.

LIST OF MEMBERS.

(*Those Municipalities in large type are represented on this Council.*)

COMMITTEES.

Date of Election.		Date of Election.	
1905	Aberdeen	1896	BRISTOL
1902	Accrington	1896	Burnley
1901	Ashton-under-Lyne	1906	
1897	Ayr	1904	Burton-upon-Trent
1906	Barking	1899	Bury
1900	Barnsley	1910	Cambuslang
1898	BARROW-IN-FURNESS	1907	Canterbury
		1897	Cardiff
1897	Bath	1900	Carlisle
1906	Beckenham	1896	Cheltenham
1896	Bedford	1898	CHESTER
1902	Birkenhead	1901	Chesterfield
1904	BIRMINGHAM	1912	Clacton-on-Sea
1908	Blackburn	1900	Colchester
1897	Blackpool	1900	Colne
1896	Bolton	1912	Colwyn Bay
1903	Bolton Tramways	1896	Coventry
1902	Bootle	1909	Crewe
1903	Bournemouth Tramways	1896	CROYDON
1896	BRADFORD	1900	Darlington
1909	Bridlington	1914	Dartford
1896	Brighton	1898	Darwen

Date of Election	
1898	Derby
1896	Dewsbury
1901	Doncaster
1906	Dover
1903	Dublin
1901	DUNDEE
1899	Ealing
1900	Eastbourne
1904	Eccles
1901	Edinburgh
1908	Epsom
1903	Erith
1897	Exeter
1905	Falkirk
1904	Fulham
1908	Gillingham
1896	GLASGOW
1903	Gloucester
1904	Gravesend
1899	GREAT GRIMSBY
1908	Greenock
1896	Halifax
1897	Hammersmith
1912	HAMPSTEAD
1897	HARROGATE
1899	Hastings
1902	Heckmondwike
1912	Hereford
1914	Heston & Isleworth
1902	Heywood
1908	Hornsey
1908	Horsham
1915	Hove
1901	Hoylake
1896	Huddersfield
1897	Hull
1902	Hull Tramways
1902	Ilford
1903	Ilkeston
1906	Keighley
1907	Kilmarnock
1906	King's Lynn
1896	KINGSTON-UPON-THAMES
1902	Lancaster
1901	Leeds
1905	Leek
1911	Leicester
1901	Leigh
1908	Leith
1901	Leyton
1897	Lincoln
1896	Liverpool
1903	Londonderry
1906	Loughborough
1899	Lowestoft
1896	Luton
1897	Maidenhead
1902	Maidstone
1896	MANCHESTER
1904	Mansfield
1913	Melbourne, Australia
1902	Middlesbrough
1902	Middleton
1898	Morley
1901	Motherwell
1902	Nelson
1897	Newport (Mon.)

Date of Election.	
1907	Northampton
1909	NORWICH
1903	Nottingham
1902	Nuneaton
1903	Oldham
1909	Pembroke (Dublin)
1896	Plymouth
1908	Pontypridd
1912	POPLAR
1904	Portsmouth
1901	Reading Tramways
1908	Radcliffe
1910	Rawtenstall
1896	Rochdale
1897	Rotherham
1897	Salford
1904	SHEFFIELD
1901	Shipley
1897	Southampton
1896	Southend-on-Sea
1897	Southport
1902	South Shields
1903	St. Annes-on-Sea
1898	ST. HELENS
1899	St. Pancras
1903	Stockton
1903	Stoke-on-Trent
1898	Stockport
1896	SUNDERLAND

Date of Election.	
1913	Sutton Coldfield
1902	Swansea
1902	Swindon
1896	Taunton
1909	Todmorden
1897	Torquay
1896	Tunbridge Wells
1903	Tynemouth
1901	Wakefield
1896	Wallasey
1896	Walsall
1908	Warrington
1897	Watford
1913	West Bromwich
1897	WEST HAM
1906	Weymouth
1912	Whitehaven
1901	Wigan
1900	Willesden
1908	Wimbledon
1912	Winchester
1906	Wishaw
1898	Wolverhampton
1906	Woolwich
1896	Worcester
1913	Worksop
1903	Wrexham
1901	York

ELECTRICAL ENGINEERS (MEMBERS).

Names of Members of Council are in larger type.

Date of Election.		
1901	Acland, R. L.	Chesterfield
1900	Atchison, C. C.	Rochdale
A 1902 M 1908	Allen, Sidney	Wolverhampton
1909	Allen, W. H.	Loughborough
1902	Angus, H. W.	Eccles
1914	Annetts, A. W.	Morecambe
1895	Applebee, N.	Ashton-under-Lyne
1906	Ayton, F. (*Past Member of Council* 1915)	Ipswich
1912	Ayton, R.	Winchester
1903	Bache, W. J.	Cheltenham
1913	Barham, A. W.	Watford
1903	Barker, E. A.	Barnsley
1910	BEAUCHAMP, J. W. ..	West Ham
1913	Beckett, A. J.	Bridlington
1903	Bell, H.	Hull
A 1896 M 1899	Bell, J. A.	Aberdeen
1913	Bellamy, L. C. F. ..	Ilkeston
1914	Bemrose, J.	Leek
1912	Bexon, W. C.	Kilmarnock
1908	Black, A. S.	Southport
1896	BLACKMAN, A. ..	Sunderland
1912	Blake, A. W.	Willesden
1907	Blascheck, C. A.	Canterbury
1908	Bloxam, T. W.	Belfast
1908	Bolam, J. H.	Weymouth
1896	Boot, H. (*Past Member of Council* 1906)	Tunbridge Wells
1906	Bowden, J. H.	Poplar, E.
1901	BRITTON, S. E. ..	Chester
1898	Brydges, J. K. (*Past Member of Council* 1908)	Eastbourne

Date of Election.		
1905	Bulfin, I.	Bournemouth
A 1896 M 1898	Burnett, H. R.	Barrow-in-Furness
1915	Burr, J. W.	Swansea
1901	Calvert, E.	Finchley, N.
1902	Campion, R. H. ..	Dewsbury
1907 1913	Chalmers, A. D... ..	Gillingham
1900	CHATTOCK, R. A. (*President* 1913–14)	Birmingham
M 1895 A 1898 M 1900	Christie, J. .. .. (*Past President* 1911.)	Brighton
A 1896 M 1898	Clegg, Stanley	Lincoln
1902	Clothier, J. H.	St. Anne's-on-Sea
A 1898 M 1902	Clothier, T. D.	Bootle
1902	Cooke, W. H.	Luton
A 1895 M 1900	Cooper, A. G.	Colne
1914	Corson, F. H.	Gloucester.
A 1900 M 1904	CRAMB, A. C. .. .. (*President* 1915–16)	Croydon
1913	Craven, G. F.	Reading
1909	Cross, E.	Rotherham
1900	Crowther, J. A... ..	Wallasey
1901	Crowther, J. P... ..	Worksop
1902	Davidson, C. S... ..	Mortlake, S.W.
1913	De Renzi, A. J. C. ..	Newcastle-under-Lyne
1896	Dickinson, H. (*Past Vice-President* 1901)	Liverpool
1908	Dimmack, A.	Swindon
1895	EDGCOME, J. E. (*Hon. Treas. Past Pres.* 1906, *Hon. Secretary* 1904)	Kingston-upon-Thames

Date of Election.		
1895	Ellis, A. (*Past Member of Council* 1902)	Cardiff
1912	Ellis, H. S.	South Shields
1909	Everitt, H. W.	Clacton-on-Sea
A 1896, M 1899	FEDDEN, S. E. .. (*Past President* 1907)	Sheffield
1903	Ferguson, R. F. ..	Hastings
1903	Foale, W. S.	Portsmouth
1909	Francis, O. F.	Kirkcaldy
1899	Furness, C. (*Past Member of Council* 1915)	Blackpool
1905	Garside, F.	Aldershot
1912	Gibson, S. Cameron ..	Nuneaton
1901	Gill, J. C.	Peterborough
1903, 1913	Gilling, A. C.	Epsom
1906	Goslin, E. T.	Glasgow Trams
1901	Grey, H.	Accrington
1911	Hall, T.	Burton-upon-Trent
A 1906, M 1908	Hame, J. W.	York
1906	Hatton, E.	Newcastle-upon-Tyne
1904	Hewlett, E. H.	Mansfield
A 1898, M 1900	Hoadley, E. E. (*Past Member of Council* 1907)	Maidstone
1910	Hogarth, L. B.	Whitehaven
A 1899, M 1903	Hollingsworth, E. M. ..	St. Helen's
1914	Holmes, W.	Barking
1914	Howie, H. A.	Walsall
1907	Jackson, W. A.	West Bromwich
1913	Kay, Barnes	Haslingden
1914	Keats, G. W.	Woolwich
1909	Kerr, W. T.	Hereford
1903	Kinghorn, D. M. ..	Southwark, S.E.
1900	Knight, J. D.	Ealing, W.

Date of Election		
A 1896 AM 1898 M 1905	LACKIE, W. W. .. (*Past President* 1910)	Glasgow
1906 1913	Leach, R. B.	Heywood
1913	Lee, H. Tomlinson ..	Wimbledon
1898	Lewis, F. H.	Leytonstone, E.
1909	Lomax, R.	Stockport
1908	Long, E. D.	Grays Thurrock
1903	LONG, F. M. (*Senior Vice-Pres.* 1915–16)	Norwich
A 1896 M 1901	Lunn, J. R. P.	Darlington
1901	Macrory, R. V.	Londonderry
1903	Marshall, R.	Ayr
1908	Mathias, F. V. L. ..	Warrington
1914	May, W. R.	Lowestoft
1903	McInnes, C. F.	Gravesend
1913	Miller, W. H.	Fleetwood
1911	Milnes, G. C.	Lancaster
1912	Moore, A. Nichols ..	Newport, Mon.
1895	Mountain, A. B. .. (*Hon. Secretary* 1896 *and Past Pres.* 1900)	Huddersfield
1896	Munro, H. D.	Exeter
1913	Nayler, G. F.	Nelson
1909	Nevill, H. A.	Wakefield
1896	Newington, F. A. (*Past President* 1905)	Edinburgh
A 1897 M 1901	Okell, E. G.	Plymouth
1905	Page, A.	Glasgow
1910	Papworth, J. W. ..	Stirling
1898	Parkinson C. F. ..	Paisley
1904	Pauls, S.	Middleton

Date of Election		
AM 1903 M 1904	PEARCE, S. L. .. (*Past-President* 1909)	Manchester
1901	Pember, J. D.	Dartford
A 1896 M 1902	Phillips, R. W. L. ..	Bedford
1909	Pickersgill, A.	Cleckheaton
1909	Pickvance, G.	Wrexham
1906	Plunkett, M. P.	Tonbridge
1914	Porter, G.	Worthing
1912	Price, S. L. R.	Pembroke (Dublin)
1895	PROCTOR, H. FARADAY (*Hon. Secretary, Past Pres.* 1899)	Bristol
1909	Purse, F. W.	Carlisle
1912	Ranson, H.	Falkirk
1904	Rayner, E. S.	Doncaster
1913	Redman, W.	Shipley
1904	RICHARDSON, H. .. (*Past President* 1915)	Dundee
1904	Robertson, J. A. ..	Salford
1902	Robinson, L. L.	Hackney, N.E.
1902	Rogerson, W. M. ..	Halifax
1908	ROLES, T.	Bradford
1902	Ruddle, M.	Dublin
1904	Rutherford, A. P. ..	Leith
1911	Rycroft, P. E.	Hounslow
1911	Salt, C. W.	Torquay
1908	Sankey, B.	Port Elizabeth
1902	SEABROOK, A. H. .. (*Junior Vice-Pres.* 1915–16)	St. Marylebone
1909	Senior, J.	Mexborough
M 1897 A 1898 M 1915	Shallcross, G. P.	Birkenhead
1901	Shaw, A. H.	Ilford, E.
1903	Shaw, C. M.	Worcester
1906	Slevin, J.	Wigan

Date of Election		
1906	Smith, Arthur T. ..	Leigh, Lancs.
1914	Smith, C. B.	Hove
1903	Smith, J. J.	Stockton-on-Tees
1912	Smith, T. R.	Leicester
1903	Spark, J. W.	West Hartlepool
1904	Staniland, N.	Hornsey, N.
1906	Starkie, J. E.	Burnley
1910	Stewart, C. L. E., ..	Rawtenstall
1910	Stokes, H. P.	Bexley Heath
1901	Street, H. F.	Southampton
1895	Talbot Herbert .. .. (*Past President* 1908)	Nottingham
1909	Tapper, J. E.	Beckenham
A 1896 M 1900	Tapper, W. C. P. ..	Stepney, E.
1902	Taylor, H. M.	Middlesbrough
1898	Teague, F.	Bath
A 1896 M 1906	Teasdel, J. E.	Pontypridd
1913	Torpy, R.N.	Tunbridge Wells
1910	Tough, G.	Coventry
1909	Tudman, A. R. ..	Colwyn Bay
1900	Turnbull, C.	Tynemouth
1907	Turner, C.	Hoylake
1901	VIGNOLES, W. A. ..	Grimsby
1911	Walker, W. A.	Kettering
1898	Watson, S. J. .. .. (*Past President of Council*, 1915)	Bury
1910	Webber, H.	Keighley
AM 1904 M 1905	Wheelwright, P. P. ..	Blackburn
1909	Whysall, F. H.	Greenock
1897	WILKINSON, G. .. (*Past President*, 1912)	Harrogate
1914	Wilkinson, H.	Radcliffe

Date of Election.		
1903	Wilkinson, J.	Hull Tramways
1895	Wilmshurst, T. P. (*Past Pres.*, 1904)	Derby
1907	Wilson, W. H.	Sleaford
1911	Wishart, J. A.	Motherwell
1913	Wood, W. J. H.	Bolton
1906	Woodman, L. W. ..	Dover
1897 M 1902	WYLD, W. (*Member of Council*)	Hampstead
A 1896 M 1905	Yeaman, C. H.	Stoke-on-Trent

HON. MEMBERS.

M 1898 1905	Chamen, W. A. (*Past Pres.*, 1901)	Cardiff
M 1896 1903	Holmes, A. B. (*Past Mem. of Council*, 1898)	Liverpool
M 1895 1911	Rider, J. H. (*Past Pres.*, 1901–2)	London
M 1898 1913	Shawfield, C. E. C. (*Past Pres.* 1912–13)	Wolverhampton
M 1906 1909	Snell, Sir J. F. C. (*Past Pres.* 1902-3)	London
M 1895 1910	Wordingham, C. H. .. (*Past President* 1898)	London

ASSOCIATE MEMBERS.

CHIEF ASSISTANT ENGINEERS

1912	Hudson, J. Barcroft ..	Bootle
1905	Lamb, C.	Dundee
1907	Ratcliff, H. A.	Manchester
1910	Yorke, W.	Sunderland

ASSOCIATES.

ASSISTANT ENGINEERS.

Date of Election		
1903	Boyce, J.	Todmorden
1911	Bush, V. F.	Redditch
1901	Cairns, R.	Glasgow
1902	Channon, A. S.	Grimsby
1903	Day, S. E.	Bury St. Edmunds
1910	Dent, J. H.	Loughborough
1906	Douglas-Arden, G... ..	Derby
1904	Fairchild, J. C.	St. Annes-on-Sea
1915	Farndon, F.	West Ham
1899	Gilbert, A. C.	Edinburgh
1911	Hooper, W. P.	Dewsbury
1901	Howell, A.	Hornsey, N.
1904	James, E. W.	Hounslow, W.
1902	Jones, S. Derwen	Batley
1909	Lunn, E.	Huddersfield
1897	May, H. S.	London
1912	McDonnell, E.C.	Bootle
1902	Millington, W. G.	Peterborough
1899	Milton, C. O.	Maidenhead
1903	Nixon, A. T.	Sheffield
1902	Ogden, F. L.	Oldham
1896	Philpott, G. J.	Brighton
1904	Rolling, B. I.	Glasgow
1911	Saxton, C.	Bradford
1902	Thomson, J.	Leith
1898	Turner, J. W.	Huddersfield
1902	Young, W.	Stepney, E.

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AYTON, F.	Cheapening of the Cost of Mains and Services	1910
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	The Use of Electric Vehicles in Municipal Service	1915
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BAYNES. S. W.	Steam Turbines	1906
BEAUCHAMP, J. W.	Modern Wiring Practice	1911
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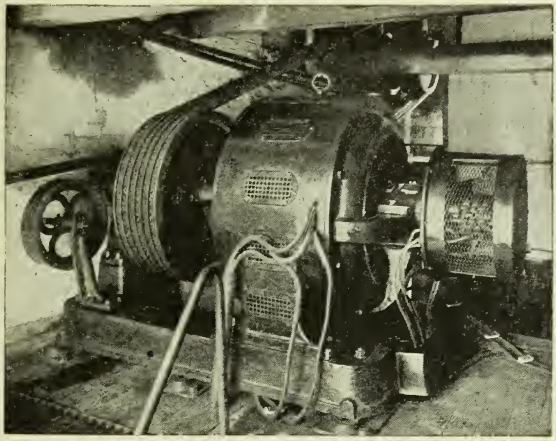

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PROCEEDINGS OF THE TWENTY-FIRST ANNUAL MEETING OF THE INCORPORATED MUNICIPAL ELECTRICAL ASSOCIATION,

HELD AT THE INSTITUTION OF ELECTRICAL ENGINEERS, LONDON,

ON THURSDAY & FRIDAY JUNE 22nd & 23rd, 1916.

REPORTED BY ARRANGEMENT WITH "ELECTRICAL ENGINEERING."

The Association is not as a body responsible for, or necessarily in agreement with, the views and opinions expressed either by the authors of the papers or by the speakers.

The Association met at 10 a.m. on Thursday, June 22nd, at the Institution of Electrical Engineers, Victoria Embankment. The President, Mr. A. C. Cramb, opened the proceedings and read his Presidential Address.

A discussion then took place on Mr. W. W. Lackie's paper on "Boiler House Design and Operation." The meeting was resumed in the afternoon, and papers on "The Generation of Electricity on a Small Scale, or Bulk Supply" by Mr. Harry S. Ellis, and on "The Application of Electricity to Agricultural Purposes" by Mr. W. T. Kerr, were discussed.

On Friday morning the Annual General Meeting was held. The Council's Report was adopted, the Officers and Council for the ensuing year were elected and other business transacted. The proceedings then terminated.

Presidential Address, June, 1916.

By Mr. A. C. CRAMB,

Chief Electrical Engineer, Croydon.

The past year during which it has been my privilege to fill the office of President marks not only the coming of age of the Association, but also the second year of the terrible struggle which has caused the time and thoughts of members to be occupied to a great extent in matters appertaining to the war, so much so that this important stage in the work of the Association passes almost unnoticed.

Some members have joined the forces, while others are giving their time and energies to supplying the necessary electric power to meet the rapid and vast expansion of the workshops of the country to satisfy the many demands of the Navy and Army; others again are devoting themselves as far as possible to assisting the various organisations for the production of munitions.

The rather moderate results of the year's work by the various Committees is therefore, I feel, quite excusable, in view of the temporary deflection of energy in directions more immediately important.

In attempting to look into the future of Electric Supply, one feels that in this as in most other matters, things will never be quite the same again. I imagine that when the country settles down to peaceful times people will aim at and expect greater efficiency and progress in business, and that in co-operative action quicker and better results will be attained.

The Electrical industry needs in a greater degree the spirit of co-operation in furthering the expansion of its work for the benefit of the Empire and of its own members. When one considers the need for progress in standardization, in publicity, in the field of domestic heating and cooking, and in the development of new lines of business, there can be little doubt that the future offers full scope for the energy of the Association.

The position of our Association is somewhat unique since it represents commercial enterprises controlled by local authorities whose main work is administrative. There is no doubt that it is difficult for officials, and even members of such bodies, whose training or main experience is administrative, to regard Electrical Undertakings in the correct perspective, with the result that there is often a cramping influence unconsciously exercised. In some minds the only justification for the existence of such Undertakings is their ability to relieve the rates, if not the ratepayers. The only reason I have heard advanced for appropriating electricity profits to this end is compensation for the risks run by the ratepayers in guaranteeing the capital.

As a ratepayer I would much prefer to pay only such prices as are necessary to cover the charges of the Undertaking itself, and equally my fair proportion of the expenses chargeable as rates. One is not more enamoured of this system of finance by the fact that frequently the most persistent advocate of charging higher prices for electric supply to relieve rates is not a user of electricity.

Model General Conditions of Contract.

There can be little doubt in the mind of any member of this Association of the necessity for standard conditions of Contract. It is necessary therefore that individuals should not press their own personal ideas, one might say prejudices, to the extent of preventing the establishment of conditions acceptable by the majority. If progress is to be made, the mature opinion of the majority must be loyally accepted. Municipal engineers have in the past enjoyed the privilege of making contracts in which the contractor had little voice, and no doubt the settling of contracts in which both sides meet on more equal terms may be somewhat disconcerting at first.

The Council have not yet received any report from the Association of Municipal Corporations regarding the contentious clauses of the Model Conditions referred to them for consideration by this Association nearly two years ago. In the meantime individual Undertakings represented on this Association are accepting these conditions, and they have, I understand, been adopted by the other representative bodies concerned.

I.M.E.A. Bill.

The Association are indebted to the British Electrical and Allied Manufacturers Association for their kindly offices in endeavouring to bring about a settlement of the outstanding differences between the Electrical Contractors Association and ourselves in connection with this Bill. A joint meeting took place and it was hoped that an agreement had been reached, but the terms, as on previous occasions, were not accepted by the Electrical Contractors Association.

Our Association has made concession after concession without avail, possibly going even beyond the limits which justice to the Undertakings they represent would warrant.

The British Electrical and Allied Manufacturers Association have studied the Bill and expressed themselves satisfied that the conditions are fair and reasonable.

I wonder how long this policy of obstruction by a small section of the Industry will be allowed to continue to seriously curtail the development of the business, not only of Electric Supply Undertakings, but also of Manufacturers and Contractors. Even when contractors are guaranteed in the Bill that all wiring work, which would be greatly increased by the passing of the Bill, is to be placed in their hands, that Supply Undertakings are to be limited to prices which contractors can safely underquote, and that increased business will be brought about through hire and hire-purchase systems in which there would be no bad debts, they appear to have so little confidence in themselves that they still hesitate to join in a course which holds the promise of a considerable expansion of profitable business. Because a few supply engineers in days gone by have expressed impatience at the lack of initiative of certain contractors an impression has got abroad that supply engineers are anxious to dispense with the contractor. There is little justification for this view; indeed the Bill would strengthen their position; but contractors must realise that the policy of "Get on or Get out" should be equally applicable to them as to others. Parliament has already in a number of cases granted much greater powers than those asked for in the Bill, and the present state of affairs, in which one Undertaking holds powers to develop its business which are denied to a neighbouring Undertaking, is extremely illogical.

The Association will, of course, at an opportune time again press for the Bill, and although there may be a further delay, the powers will come and possibly in a much fuller form than is now asked for.

In the meantime the Electrical Industry must bear with what patience it can the contemplation of the large amount of business which is being lost to Gas Undertakings which are not so handicapped.

It has been the aim of this Association to effect an agreement equitable to the various interests, but it may become necessary to adopt a more active policy to create a greater desire for settlement.

Development Committee.

It is a matter of regret that in view of the important work awaiting this Committee little progress has been made, but members have found it impossible to spare the necessary time during the past year.

The work of the Sub-Committee dealing with questions of electrical apparatus for cooking, heating, and other domestic requirements is urgent and important. There is here a wide field ready for development; it is true the non-passage of the Bill blocks the main possibilities of business, but still much can be done in the meantime. There has been too much disjointed work in the production of cooking apparatus and a co-operative effort by manufacturers and supply authorities is urgent. There are many matters of detail, but of great importance to success, which actual experience has demonstrated require consideration. American apparatus, although of light design and therefore not altogether suitable for British use, shows a better appreciation of the requirements necessary for satisfactory operation. The production of a suitable and reliable radiant heating unit in place of the usual hot plate is a case in which the work of the Committee should yield good results.

It is highly probable that valuable assistance could be rendered by the National Physical Laboratory in solving certain problems connected with electric heating and cooking.

The Publicity Sub-Committee has been instructed to prepare a complete scheme for the development of a Publicity Organisation in this country.

Several attempts have previously been made in this direction, but in all cases have ceased after a certain period. Undoubtedly the question of sufficient funds has been the main obstacle. A first essential of success is the appointment of a thoroughly competent whole-time specialist in publicity, who should give his entire attention to the running of such an undertaking. A more liberal spirit of co-operation of the various interested parties is of equal importance. The hanging up of the I.M.E.A. Bill—which contains provision for enabling Local Authorities to subscribe to such an organisation—also continues to prevent progress.

The Summer-Time Act will reduce the revenue of Electrical Undertakings, and in the case of those depending mainly on lighting for their income its effect must cause concern as to financial results.

The passing of this Act serves to emphasise the courage and foresight of those undertakings which had adopted the Norwich or some other system of standing and running charges for domestic purposes before the use of metal filament lamps became general. Although the basis for arriving at the standing charges in these cases may possibly be considered open to criticism, still in practice they have been found fair and workable, and the advantage to the undertaking by the adoption of such a system, in maintaining financial stability against the large drop in revenue resulting from the introduction of more economical lamps and other causes, far outweighs any such objections.

The loss of revenue resulting from this Act brings home the importance of the development of the use of electricity for other domestic purposes. Gas undertakings, through having developed the heating and cooking lead, can regard the loss of revenue in this direction with less concern.

My own experience in bringing before the householder the merits of electricity for domestic purposes has convinced me that there is a very large potential demand if only the Electrical Industry is ready with a supply of suitable

apparatus which can be obtained by consumers on terms comparable with those to which they have become accustomed.

One might here take the opportunity of expressing the hope that Electricity Committees realise that those members of the staff who have to deal with the development of electricity for domestic purposes, should take every possible opportunity of gaining actual experience with various types of apparatus in their own homes, and that all reasonable facilities should be given to this end.

Coal Supplies.

The question of sufficient supplies of coal for the maintenance of Electricity Undertakings has been a source of anxiety during the past year to the individual members of the Association, and promises next winter to become critical.

The Council have done what is possible by appointing a Sub-Committee to watch the question and by supporting representations to Parliament and the Board of Trade.

It should be realised that the Government are in a position of considerable difficulty in regard to this matter, and that although they have apparently not been able to give much material assistance to individual Undertakings, at the same time there is reason to believe that in view of the many demands on them they have endeavoured to help as far as possible with due regard to other claims of equal importance.

The proposal of the Board of Trade to urge consumers to make a percentage reduction in lighting with a view to economy in coal is not likely to have the desired effect. The provision of a large number of extra meter readers

would greatly increase expenses, the annoyance to consumers of frequent visits would cause unnecessary friction probably without effecting any appreciable economy. The view of many Supply Authorities that an increase in price is the more effective way of bringing about economy is undoubtedly correct.

It seems to have been overlooked that lighting restrictions and the reduced available monies of most users have already brought about a very considerable reduction.

The saving in coal owing to reduction of lighting seems also to have been greatly over-estimated, but it is the duty of every one, nevertheless, to help the Government in every reasonable way to increase the amount of coal available for export.

It is to be hoped that the present interest of the Government in national economy of coal will last beyond the war.

British Engineering Standards Committee.

The work of this Committee has been approved by the Government, from whom they receive financial assistance.

The Council are also giving support by subscribing to the expenses, and your Association is well represented on the various Committees of the Electrical section. My experience on certain of these Committees convinces me that the work, if carried on with energy and in a spirit of broadmindedness, will bring valuable results to the undertakings represented by this Association, through standardization tending to improve design and cheapen the cost of manufacture. I hope, therefore, that local authorities will be prepared to help forward this work by subscribing.

Financial Control.

It can be easily understood, and experience has largely proved, that the control of accounts by an official independent of the Engineer-Manager inevitably leads to unsatisfactory results. In very many cases a complete set of books in duplicate have to be kept so that the Manager can properly watch over the working results. Nowadays the chief official of an Electric Supply Department must, to an increasing extent, devote his energies to the financial and commercial side of the business; at the same time his training and experience enables him to guide the work of the technical staff. From the logical point of view of a ratepayer it would be much more satisfactory if the Municipal Accountant, apart from matter of loans at any rate, were to act as an internal auditor.

Constitution of the Council.

The Constitution of the Council has in recent years been fully reviewed by the members, but some still urge that the Council should contain a definite minimum number of members representing small undertakings. This question is one for the decision of the members as a whole, but it should be borne in mind in considering this matter that the members elected to the Council should be those who, in the opinion of the majority, are likely to carry on the work to the greatest satisfaction of the Association irrespective of whether such members represent large or small undertakings. The views of the various sections, however, should be represented on the Council.

It has been further urged that with a view to enabling all members of the Association to participate in the election of officers and members of the Council, the present arrangement of voting should be changed to a postal ballot. Members will have an opportunity of deciding this point at the Annual Meeting.

British Trade after the War.

In the report of the Board of Trade Committee on British Trade after the War, it is proposed that local authorities amongst other public bodies should be under legal obligation to purchase as far as possible only goods produced in the British Empire.

It is felt by your Council that discrimination between local authorities and private companies in this matter is unjust to the ratepayers, and that whatever restrictions are made with a view to assisting British manufacturers, they should be equally applicable to all interests.

Members will, I believe, be generally of opinion that although the interests of the Association in the position of British Trade after the War are indirect, they are, nevertheless, important. The Council are therefore hoping to have their views fully set before the Electrical Trades Committee appointed by the Board of Trade to report on this question.

Members will probably be interested in the clause in the recent act of the Tunbridge Wells Corporation authorising the purchase of machinery for the Electricity Undertaking out of surplus profits. This forms a precedent which may be of value to members at some future time.

It is a matter of considerable gratification to find that during the past year an Association on similar lines to the I.M.E.A. has been formed in South Africa, and it is hoped that there will be close working and mutual assistance in the future between the two Associations.

It had been my intention during the past year to have placed before the Council some scheme whereby the members of the Association would be kept in closer touch with the various matters which the Council have had under

consideration from time to time. This would, I feel, help to maintain and probably materially increase the interest of the members in the work of the Association which at the present time tends to be confined to the duration of the Annual Convention. I regret, however, that present conditions made it inopportune to bring forward this question.

In concluding these remarks I feel sure that I am echoing the feelings of all present when expressing the earnest hope that before the Association meets again the British Empire will have gone far towards attaining the objects for which the present prodigious sacrifice of their manhood and wealth is being made.

Councillor Sinclair (Swansea) proposed a hearty vote of thanks to the President for his Address.

Mr. C. H. Wordingham, in seconding, said it was wonderful when looking back on that Meeting in the Westminster Palace Hotel at which the Association was formed twenty-one years ago what vitality had animated the Association right through its life, and this vitality seemed to be in a fair way to increasing rather than diminishing.

The vote of thanks was carried with acclamation.

The President having thanked the members for their appreciation of his Address called upon Mr. W. W. Lackie to read his paper on "Boiler-House Design."

Boiler House Design and Operation.

By W. W. LACKIE.

(*Engineer and Manager, Glasgow Corporation Electricity Department.*)

THE design, equipment and operation of a boiler-house in connection with an electricity generating station invite attention to a variety of quite distinct engineering problems, almost any one of which would require a paper to itself. In the time at our disposal attention will necessarily be confined to a general survey of the boiler-house as a whole, and it may be that passing reference to certain of the details of boiler-house design and equipment will lead to a fuller consideration and discussion of these.

Two years ago Mr. Fedden read a paper on this subject, but as coal and its economic use have been very forcibly brought before us during the past year, it was thought that a further paper and discussion on the subject might be to the advantage of all concerned.

Many considerations have now to be kept in view in the design of a modern boiler-house, but the main object has come to be, to have the maximum of steaming capacity in the minimum of space. The necessity for this has largely been brought about by the introduction of turbine-driven

generators and the ever increasing size of generating sets. Twenty years ago in the design of a generating station, it was a simple matter to install an additional boiler for each addition to the engine-room plant, as a reciprocating engine of 500 h.p., or even 1,000 h.p. with its generator occupied practically the same amount of space as the boiler plant required to supply steam to such sets. In these early stations the area occupied by the boiler-house was practically the same as the area necessary for the engine-room, and extensions were easily made. On account of the poor load factor which prevailed in these stations—due to the fact that the demand was mainly for lighting supplies, the limited area of supply, and the central site chosen for the station—economisers were seldom installed and the stations were run non-condensing.

The power per square foot in the engine-room varied, but 1 h.p. per square foot of engine-room floor space was an average figure. The boiler-house was, as a rule, a one-storey building and an evaporation of 14 lbs. of steam per square foot of boiler-house floor space, or 42 lbs. per square foot of boiler floor space, was the steaming capacity. This was considered a good average figure. The boilers were hand-fired and the coal store was the floor in front of the boiler or a bunker in front of and practically on the same level as the boiler. All ashes had to be removed by hand on to the boiler-house floor or direct into hand-barrows to be wheeled away at any convenient time.

A few years later, when it began to be recognised that the supply of electrical energy for power purposes was an economic possibility and larger stations were being erected, the power per square foot of engine-room space was not seriously increased, as condensing engines were installed, and the space required for condensers increased the size of the engine-room and increased the total space occupied by the steam using plant. Larger boilers were used, but economisers were then installed, and these were, as a rule, on the boiler-house floor level, and the

evaporation per square foot of boiler-house space was not seriously increased.

The further growth in the demand for electric energy, the much improved load factor, and the introduction of the use of the steam turbine for the driving of electric generators about the year 1904, brought about a distinct change in the relative space required for engine-room plant and boiler-house plant. The turbine-room came to consist of a two-storey building, the condensers being on the ground floor or basement floor, and the turbo-generators on a floor above. Instead of having 1 h.p. per square foot of engine-room floor space, we have to-day turbine rooms with 5 h.p. per square foot, and in designs for new power stations, using 15,000 to 30,000 kw. sets, this figure may go up to 20 h.p. per square foot of engine or turbine-room floor space.

With this enormous increase of power per square foot of turbine-room, changes in boiler-house design are absolutely imperative, particularly in the lay-out of the boilers, otherwise the space occupied by the boiler-house will be out of all proportion to the space allotted to the turbine-room.

It is now recognised that even with improvements in boiler-house design, where very large turbo-generators are in use, every pair of such sets requires a separate boiler-house. Several present-day power houses have an evaporation of 50 lbs. of water from and at 212° F. per square foot of ground space occupied by the boilers, but it is possible with improved design of the boiler-house plant to approach an evaporation of 100 lbs. from and at 212° F. per square foot of the ground space actually occupied by the boilers. We therefore find that while the engine-room floor space and the boiler-house floor space were twenty years ago about equal and remained so even for ten years thereafter, to-day in a large modern generating station the ground space occupied by the boiler-house is from $1\frac{1}{2}$ to $2\frac{1}{2}$ times the space occupied by the turbine-room.

The first consideration is to ensure the maximum grate area per square foot of boiler-house floor space, and it appears that burning coal with natural or induced draught at from 25 to 30 lbs. per square feet of grate area there is a limit to the maximum possible continuous output per square foot of grate area and that consequently there is a limit to the maximum power per square foot of boiler-house floor space. Arranging the boilers and economisers all on one floor practically doubles the area of the boiler-house; and in a modern boiler-house anything which adds to the area is to be avoided, wherever possible. It is in fact now recognised that a modern boiler-house should consist of three storeys at least: the basement or ground floor containing ash-handling plant; the second floor containing the boilers proper, and the third or upper floor containing economisers and coal conveying machinery and probably coal storage in the form of overhead hoppers above the boilers. Draught fans may be placed on any one of the three floors.

The question of chimneys and chimney draughts is by no means settled, but in stations where boilers of 50,000-lbs. capacity are installed it is necessary to erect a separate chimney for each boiler or each pair of boilers. One is practically compelled to adopt steel in preference to brick for chimneys in a modern boiler-house, as with steel the chimney can be erected from the third floor, on which the economisers are placed, whereas if brick is used, foundations have to be laid on the basement or ground floor and the structure continued to the third floors, at which point only it comes into useful commission. The brick chimney foundations and superstructure up to the second floor simply mean a waste of valuable space and a mass of brickwork which serves no useful purpose.

It is desirable not only to deal with ashes ejected from the boilers, but also to deal with riddlings and any semi-burned fuel. These riddlings have to be returned to the coal-conveying plant and thence to the overhead coal hoppers so as to be used again in the furnace.

The necessity for concentration of power has made the water-tube boiler indispensable for the modern power house. Even with this type of plant the assembling of the heating surface over the grate area is undergoing modifications in order that the highest possible evaporation per square foot of ground space may be obtained. The evaporative capacity of a boiler depends in a large measure upon the grate area, or, in other words, the quantity of coal which can be burned underneath it, provided sufficient air is supplied to burn the fuel, and that the elements of the boiler are such as will absorb the heat, and consequently the maximum concentration of power is obtained when the whole of the generating and recuperating surface is assembled directly over the grate.

The water tube boiler has undergone considerable development during the last twenty years. It has passed through at least five stages. There was first big water tubes with brick casing $\frac{1}{2}$ inch draught, $\frac{1}{4}$ inch of this being used in grate, high efficiency, 25 to 30 lbs. of coal per square foot of grate area, good-sized coal being used. Passing the next three stages which were modifications of stage No. 1, we reach the present stage with the marine type of boiler, $\frac{1}{2}$ inch to 1 inch induced draught, close link grate, low grade fuel, additional forced draught on grate 1 inch to 2 inches, 35 to 45 lbs. of coal per square foot of grate area, and high efficiency.

The space actually occupied by boilers at present with the necessary passages between, does not as a rule exceed 33 per cent. of the total boiler-house floor space, and of this 33 per cent. the grate area only accounts for one-half.

Let us consider the case of a boiler-house which has to supply steam to two 15,000 kw. sets. The steam required for each set will amount to between 180,000 and 200,000 lbs. of superheated steam per hour. This steam under modern conditions would be supplied by four boilers, each capable of generating 50,000 lbs. of steam. Each boiler will require to burn at least 7,000 lbs. of coal per hour depending upon

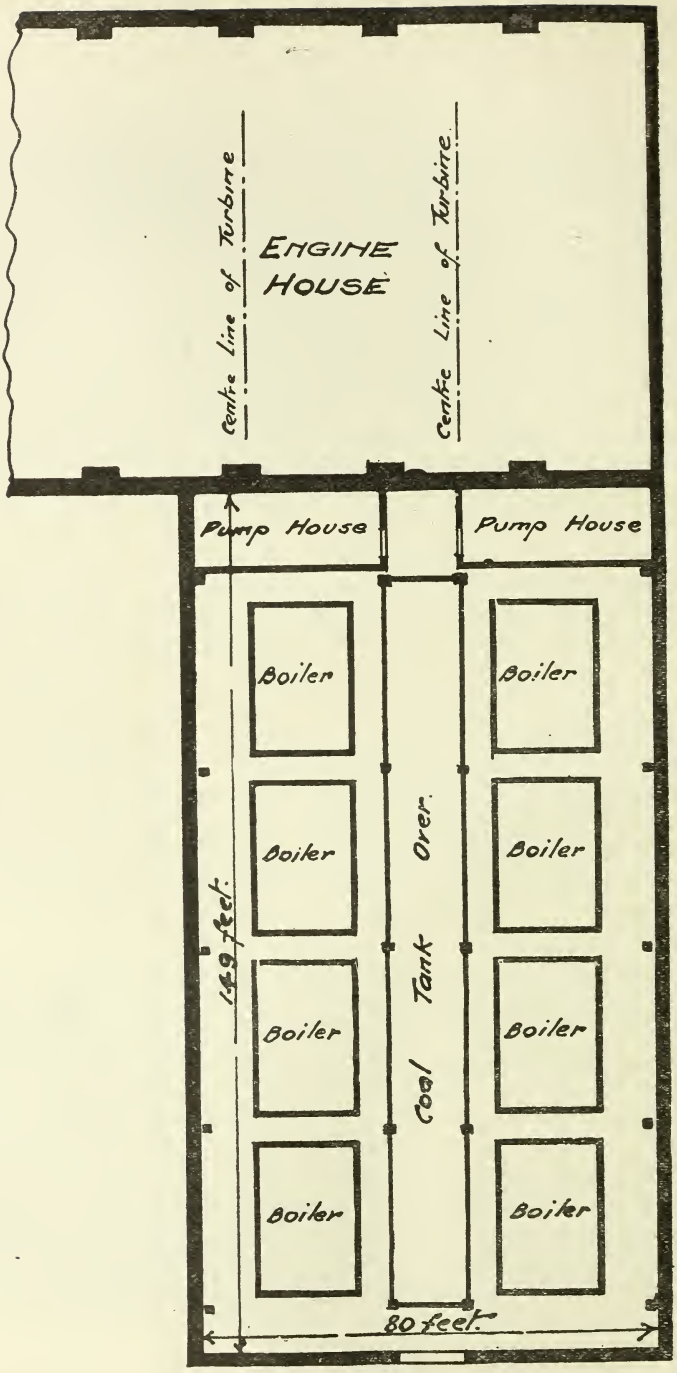
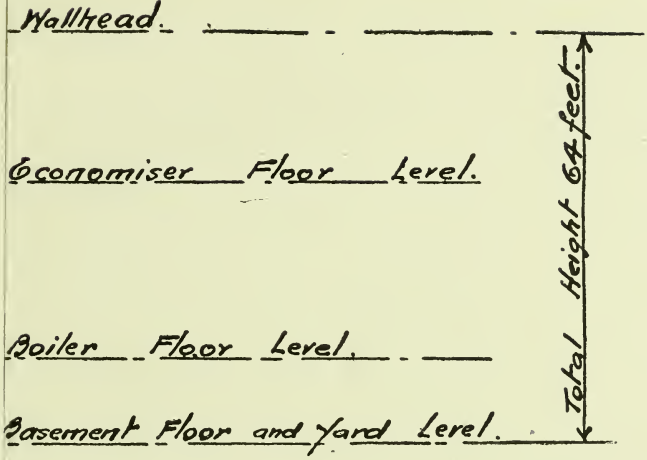


FIG. 1 – PLAN OF BOILER HOUSE.
Scale 30 feet = 1 inch.


Wallhead.
Economiser Floor Level.
Boiler Floor Level.
Basement Floor and Yard Level.
Total Height 64 feet.

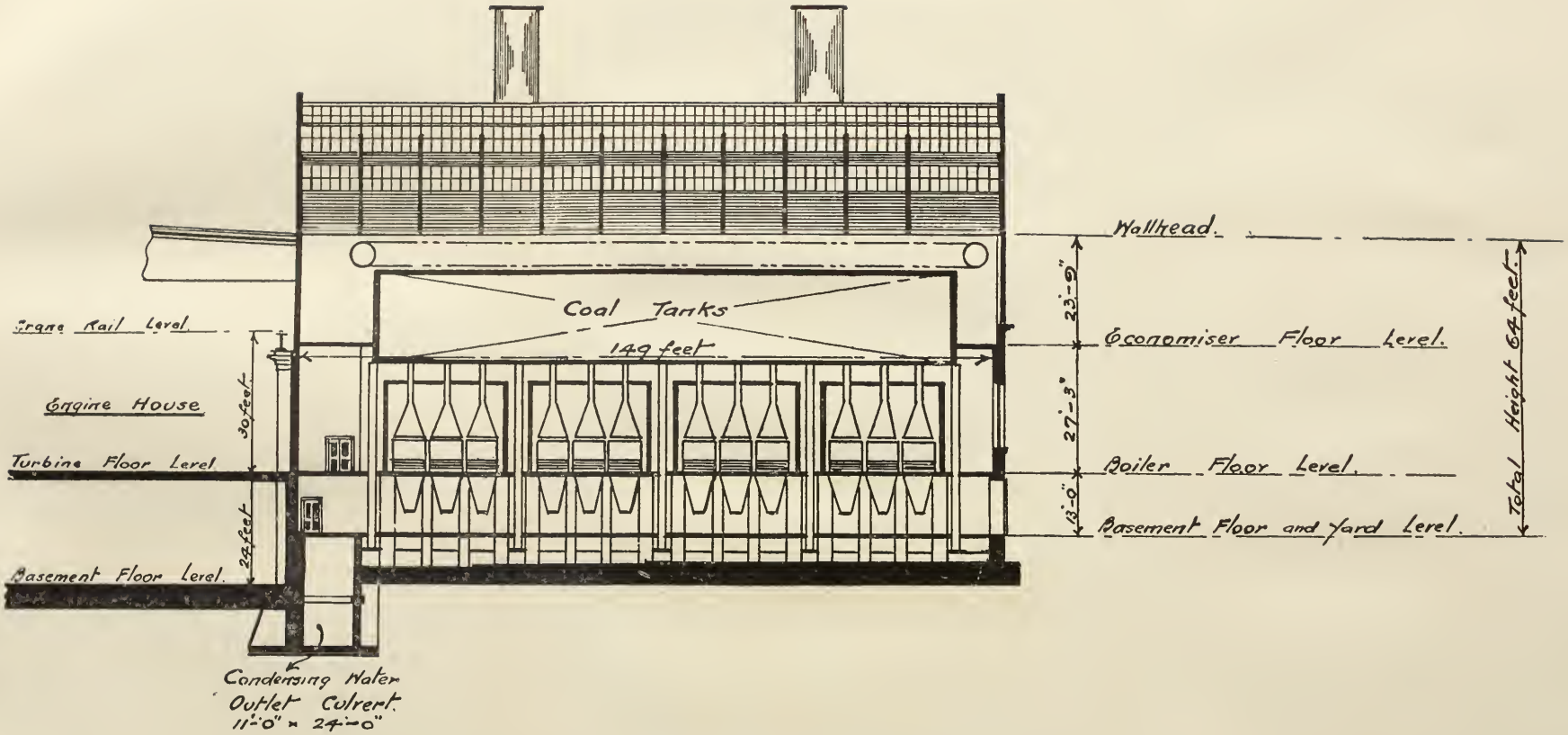


FIG. 3.—LONGITUDINAL SECTION OF BOILER HOUSE.
Scale 30 feet = 1 inch.

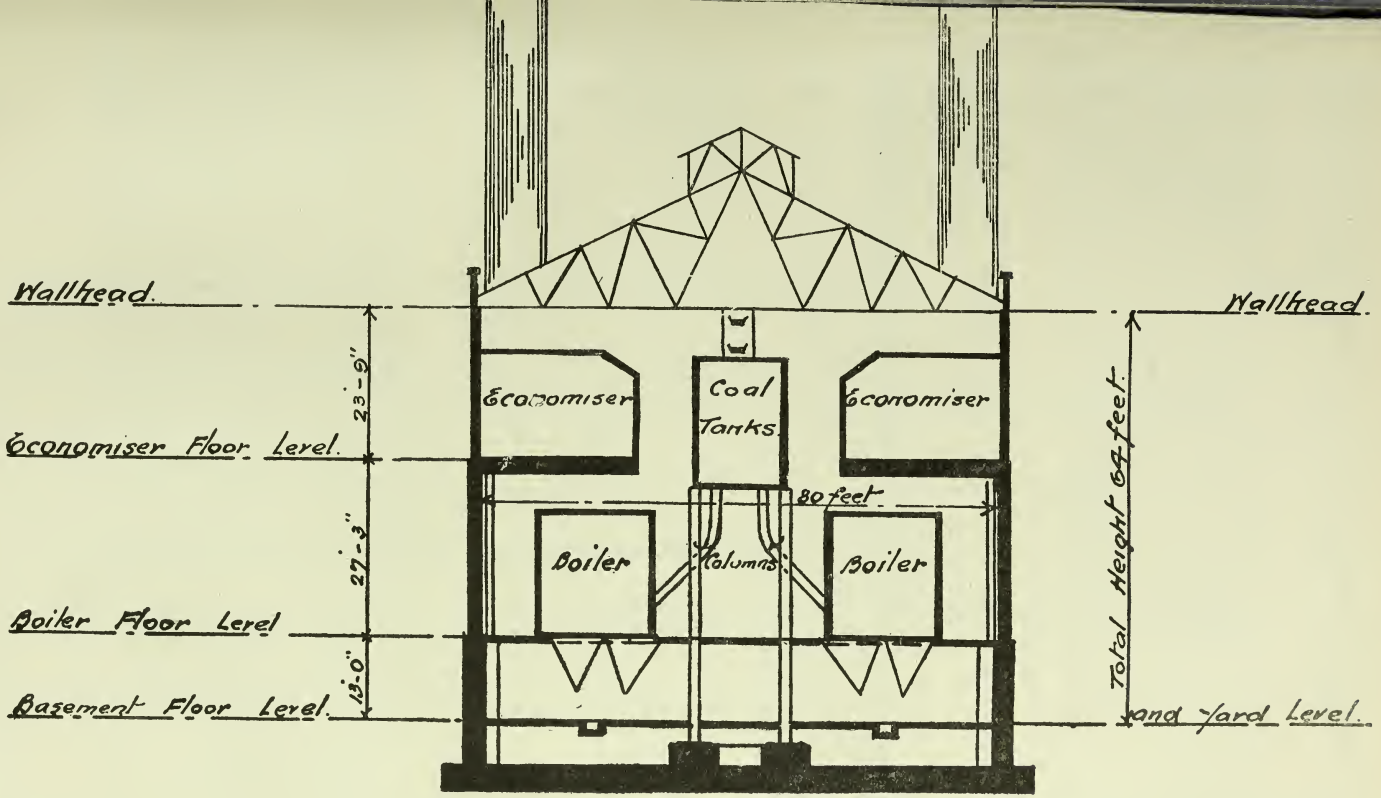


FIG. 2.—CROSS SECTION OF BOILER HOUSE.
Scale 30 *feet* = 1 *inch.*

the calorific value of the coal. This means that grates of 250 to 270 square feet will be necessary. A grate area of 250 square feet means that each boiler will actually occupy, with passages between, about 500 square feet, eight boilers will require 4,000 square feet, and the boiler-house will have a floor area of 12,000 square feet. Fig. 1 shows a plan of such a boiler-house, Fig. 2 is a cross-section, and Fig. 3 a longitudinal section.

From what has been said it is clear that increasing the size of the boiler unit will not of itself seriously increase the power per square foot of floor space. Twenty years ago water tube boilers of 4,000 to 6,000 square feet heating surface were considered large. To-day boilers are made with a heating surface from 10,000 to 20,000 square feet. In Detroit five boilers each with over 20,000 square feet heating surface are in use.

The plan of installing boilers (apart from economisers) on two floors ought only to be adopted where the exigencies of the site render such an arrangement inevitable ; that is to say where land is dear or where local building regulations limit the dimensions of buildings in certain areas. In the new station of the United Electric Light and Power Company at 201st Street, New York (notwithstanding that this district is a suburb of New York) the Company have been forced to adopt the flatted arrangement for their boiler-house in order to comply with City requirements.

The boiler-house must no longer be a stokehold with an atmosphere of grime and dust and dirt. It should be designed to admit of an ample supply of natural daylight. This is managed by placing the boilers back to back instead of face to face, with a firing floor down each side instead of down the middle between the two rows of boilers. Light can then be had from windows in the side walls as well as from the roof. This however means a larger floor area and a space between parallel boiler-houses, and further increases the ground area occupied by the power station. Such an arrangement is shown in plan on Fig. 4 and in

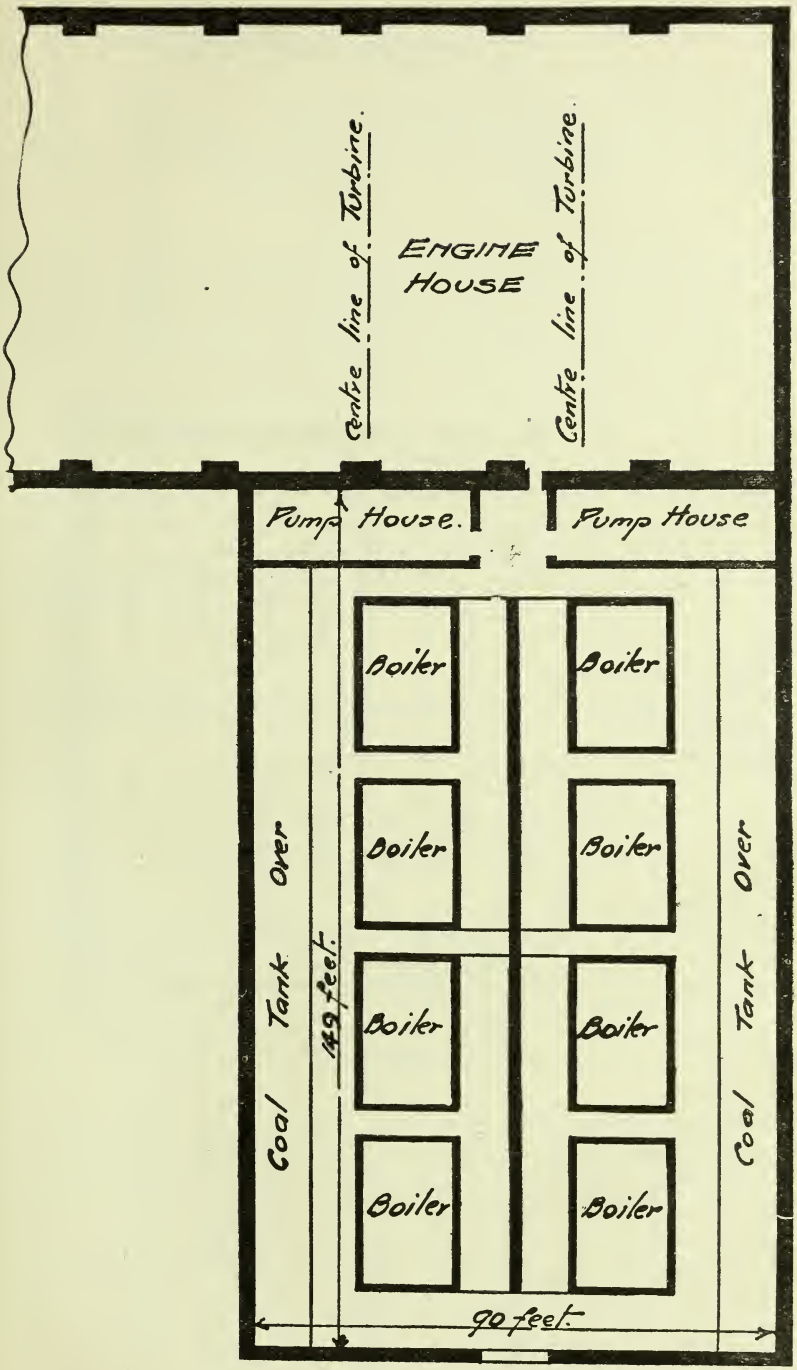


FIG. 4.—PLAN OF BOILER HOUSE.
Scale 30 *feet* = 1 *inch.*

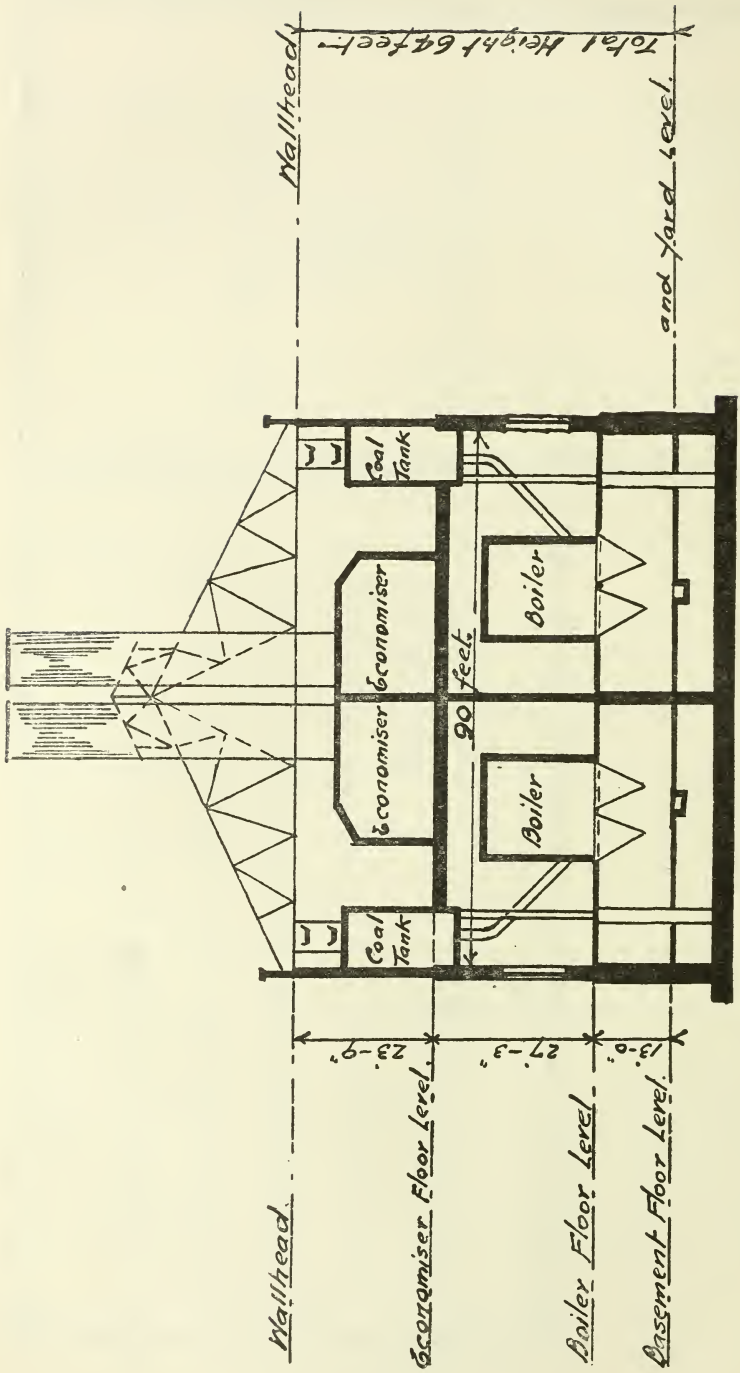


FIG. 5.—CROSS SECTION OF BOILER HOUSE.
Scale 30 *feet* = 1 *inch.*

section on Fig. 5. Adequate daylight can be got from roof lights with proper design of the roof, and Figs. 1, 2 and 3 show such an arrangement.

There is still a tendency to-day to construct the combustion chamber of boilers much too small. A combustion chamber should be of such dimensions as to allow ample space for complete combustion taking place and the products of combustion thoroughly mixing before coming on to the heating surface. The author finds that the older boilers had 2 to $2\frac{1}{2}$ cubic feet of combustion chamber per square foot of grate area. To-day similar boilers have 5 cubic feet of combustion chamber per square foot of grate area. The Detroit boilers before referred to have 9 cubic feet per square foot of grate area, and it is generally conceded that this fact is very largely responsible for the high efficiency of these boilers at widely varying loads.

It is not necessary to enter into the details of the usual fittings of boilers such as safety valves, high and low water alarums, dial steam pressure gauges and miscellaneous valves ; but it may be said that the equipment of a modern boiler should include two draught gauges. One of these should show the difference in pressure between the combustion chamber and the outlet from the boiler, *i.e.*, the difference in pressure across the boiler elements. This will be a measure of the flow of the gases through the boiler and will indicate when a boiler requires cleaning. The second draught gauge should show the difference of pressure between the ash pit and the outlet of the boiler. This second gauge will always read higher than the first and the difference is obviously a measure of the draught through the fire.

Steam flow meters are as necessary on boilers as an ammeter is on a generator, as they indicate what each boiler is doing, and whether all the boilers are doing their fair proportion of the work.

One or more CO_2 recorders have been for some years

installed as part of boiler-house equipment, and these are found to be a valuable adjunct as they are an index of the working efficiency of the boiler-house.

A word of warning, however, is required against assuming that high CO_2 always means high efficiency. There may be a large quantity of CO present. There should be thermometers or pyrometers with dial face on every boiler, giving the temperature of the superheated steam leaving the boiler, also the temperature of the gases at the damper.

Steam Piping.

With boilers of the size under discussion, steam piping should be carried from each boiler or pair of boilers to a steam drum or receiver placed on the boiler-house floor or basement floor adjacent to the wall between the boiler-house and the turbine-room. This arrangement is preferable to one large steam header. From the steam receiver a steam pipe is led to a turbine and another pipe to the next receiver so as to give interchange of steam from one set of boilers to another when required.

Appended are the results of an interesting series of tests on steam pipe and boiler drum covering materials to show their relative properties for the conservation of heat from high-pressure steam. The final temperature of the superheated steam in the power station varied from 550° to 600° F. Four firms were asked to cover three sample pipes 2 ft. long by 4 ins. internal diameter, $\frac{1}{4}$ in. thick mild steel, with standard flanges on each end. The firms asked to quote were given a free hand as to choice of the material which would best meet the conditions. The thickness of covering was specified to be 2 ins., the covering to be finished off at the flanges in a manner to suit flange cover boxes of the usual dimensions. (Appendix I.)

We may at an early date see an increase in the boiler pressure from 160 and 200 lbs. to 250 lbs. The Commonwealth Edison Company of Chicago worked the boilers in

their Fiske Street station at 200 lbs. until 1907, when they adopted 225 lbs. at their Quarry Street station, and in 1910 they adopted 250 lbs. at their North-West station.

Fuel Handling and Storage.

A station of 50,000 kw. capacity and burning 200,000 tons of coal per annum requires coal handling facilities for a supply of 1,000 tons of coal per day, together with facilities for the handling of ashes to the extent of 100 tons per day. This means a railway siding capable of holding from 100 to 120 full trucks, and probably another siding of equal dimensions to hold the empty trucks. The provision of an adequate railway siding is therefore a costly adjunct in the layout of a large power house owing to the serious addition to the site which it entails. The length of railway sidings for a 50,000 kw. station would not be less than half a mile or an addition to the site equivalent to 4,400 square yards. The wagons have to be tipped and coal conveying plant has to be provided capable of handling 100 tons per hour. Coal-breaking machinery should be installed, for while we have in the past been in the habit of using small coal, circumstances may in the near future render it economical to buy and break larger coal. This question, however, brings in the whole question of mechanical stokers, and that subject would require a paper to itself.

Large coal storage accommodation is advisable and will prove economical. Not less than from two to four months' fuel supply should be retained. This marginal stock enables coal to be delivered in fairly regular quantities throughout the year and may result in lowering coal prices. The height or depth at which coal can be stored depends upon the class of coal, and the best method of storing coal is still undecided.

The cost of lifting coal from canal barges or from trucks, and placing it overhead in coal hoppers or in the coal store, is a small item in the total price of coal.

In one Glasgow station we have a coal transporter fitted with a 1-ton grab. This transporter cost £2,600 and it handles coal at the rate of 40 tons per hour, and the cost of energy, labour and repairs on it brings the cost of handling coal in this way just under 1d. a ton. In another station truck loads of coal are elevated 30 feet at one end of the coal store to an overhead platform, whence the coal is tipped into an overhead hopper or to the coal store, and the empty trucks lowered by a second elevator at the other end of the coal store. These two elevators, complete with electrically-operated capstans, cost £2,000. The inclusive cost of handling coal in this way is $3\frac{1}{4}$d. per ton, the higher cost being due to the amount of labour necessary for handling the trucks. These figures are conclusively in favour of the grab and transporter. Where coal has to be carried a short distance from coal store to boiler-house, bucket or tray conveyors appear to be the right thing. On the other hand, for longer distances, the Telpherage system works out slightly cheaper, although the human element, with its attendant problems, enters more largely into the Telpherage system.

For the removal of ashes, bucket conveyors have proved to be costly in upkeep on account of the wear of the axles and pulleys, caused by the fine hard grit of ash dust, but even with this drawback, bucket or tray conveyors seem to be the cheapest method of removing ashes. Suction ash plant is finding much favour on account of the absence of moving parts in its design, but the capital cost is very much greater (about three times) than that of bucket conveyors. Suction plants have not yet been long enough in use to warrant any definite pronouncement being made as to repair bill. The cost for operating suction ash plant works out at about 5d. per ton handled, with energy at 1d. per B.O.T. unit. Suction plant is now made to do other work. It can be constructed for the purpose of elevating riddlings and small unburned fuel to a hopper or tank over the coal-conveying plant. It can also be made suitable for the removal of soot from economiser soot chambers and flue dust from the base of the chimneys.

The efficiency of the ordinary vacuum cleaner is well known and it appears that suction plant should be quite successful for the handling of this lighter material. The atmosphere in which all these operations are carried on is greatly improved by the action of the vacuum plant.

A modern boiler-house calls for comparatively large overhead ash storage, from which ashes can be dropped into wagons or other vehicles for their removal to a coup. The removal and disposal of ashes is becoming a serious matter. A few years ago ashes had a market value and we could get as much as 4d. or 5d. a ton for them. Then a time came when we were glad to get rid of them free of charge. To-day we have difficulty in getting the ashes from our stations carted away at 2s. a ton, paid to the carting contractor who undertakes their removal. It has been suggested that it would pay the large electrical undertakings to purchase 3-ton or 5-ton electrically propelled wagons for the removal of ashes, especially where convenient railway facilities are not available.

Coal-weighing machinery for each boiler or group of boilers is absolutely necessary if proper records are to be made of the boiler-house efficiency. It should always be possible to ascertain the amount of coal used in each 8-hour shift and at the end of each week or month, so that the coal used per kilowatt hour generated may be ascertainable. These weighing machines should preferably be fixed between the overhead coal hopper and the boiler stoker, but some stations in America have a travelling gantry, fitted with a weighing machine at each end, the gantry travelling along the whole length of the boiler-house between two rows of boilers. The duty of the operator on this gantry is to move up and down the boiler-house and to weigh out regularly to each boiler a predetermined amount of fuel.

Feed pumps may either be of the direct-acting type or centrifugal, although experience with the former is so good and repairs so low that it will be difficult to displace them.

The total condensate from the turbine-room condensers should be measured by a Lea or other water recorder and this should have an integrating attachment.

Having ascertained the amount of coal used and having measured the condensate, we can get the amount of water evaporated per lb. of coal used.

No very great increase in the efficiency of steam boilers can be looked for. The heat balance of many of the steam plants in operation at the present day is as follows :

Heat absorbed by boilers	78%
Heat lost in flue gases	15·5%
Heat lost in radiation and unaccounted for	6·5%

That is to say, the total loss on which any reduction can take place is 22 per cent., but it is only a small proportion of this figure which can be attacked with a view to lowering it. It would be doing negative work to discharge the gases from a boiler at a temperature lower than that of the water in the boiler.

An evaporation of 4 lbs. of water per square foot of heating surface in the boiler was, until recently, considered standard practice, but to-day water tube boilers are designed, in conjunction with special economisers to evaporate at the rate of 6 lbs. normal load, and at overload 8 and even 10 lbs. per square foot of heating surface of the boiler. The heating area in most water tube land boilers is of the order of 50 times that of the grate area. With such proportions the general practice is to emit the gases from the boilers at a temperature 500 to 550° F., *i.e.*, from 100 to 150° F. above the temperature of the steam at the boiler working pressure. The proportion of heating surface in economiser to heating surface in boiler varies in nearly every station, but the figure of 35 per cent. may be taken as a fair average. With such a proportion, allowing for heat drop in flues the gases at the outlet to the chimney will have a temperature of from 325 to 350° F., and the economiser will have utilised about 7 per cent. of the heat of the

gases emitted from the boiler. The inlet water to the economiser from the hotwell will, with present-day practice, be raised to a temperature of 200 or 220° F. Until recently the evaporation per square foot of heating surface of boiler and economiser combined was therefore roughly 3 lbs. per square foot of heating surface. Modern practice tends to diminish the heating surface in the boiler from 50 times the grate area to 35 times the grate area and to increase the area of the economiser to 80 per cent. of that of the boiler heating surface. The result is to put up the evaporation of the boiler at overloads to 8 lbs. per square foot of heating surface and the temperature of the gases now emitted from the boiler is considerably raised, being about 650° F. The heat, however, is taken up in the economiser and the temperature of the feed water to the boiler is considerably increased. The net result is that we get an evaporation of $4\frac{1}{2}$ lbs. per square foot of heating surface of boiler and economiser combined. The overhead economiser is suitably proportioned to give the very highest combined efficiency. Boiler plants arranged in this way probably give a higher efficiency than was the case with previous designs, inasmuch as the radiation losses are less and the loss between the boiler and the economiser is reduced to an absolute minimum.

The modern tendency is, therefore, to supply feed water to boilers at a temperature as near as possible to the temperature of the water already in the boiler and the boiler simply adds latent heat and superheat to the steam. Each boiler has its own economiser and the economiser is really an integral part of the boiler unit.

Two tests on boilers are annexed. The first was made on an ordinary land type water tube boiler supplied eight years ago. The second was carried out on a modern boiler, designed as above indicated, and the results of the test bear out the contentions with regard to evaporation per square foot of heating surface and of floor space occupied. (Appendices III. and IV.)

Fuel.

An electric power station is simply a factory for the conversion of the chemical energy in coal into electrical energy. Coal is, therefore, the raw material of the factory; and as the final product, alike as regards reliability and price, depends first and last upon the quality and the regularity of the supply of coal, the selection and purchase of fuel are matters of the most vital importance.

The selection and purchase of fuel is a question naturally dependent upon the geographical position of the site relative to the nearest coalfields, and upon the nature of the load. An excellent discussion on this subject took place at one of our Conventions a few years ago, and it is a matter for regret that there is no record or even a summary of that discussion, ably led as it was by Mr. Shawfield, then Engineer to the Wolverhampton Corporation Electricity Department.

Power stations near the coalfields can use low-grade fuel with resultant saving in the coal bill, whereas it is often more economical to use high-grade fuel in stations remote from the coalfields as the same freight has to be paid for ash as for carbon.

The kind of fuel also depends upon the nature of the load, as it is a recognised fact that a higher overload duty can be obtained from a boiler fired with good quality coal with a given draught than can be got with low-grade fuel. If a station has a purely lighting load, and consequently a low load factor, a larger number of reserve boilers with their resultant radiation losses, etc., have to be kept under steam to meet any sudden peak loads, than would be the case in a power station where the load is chiefly for power purposes and consequently the load factor is high. In the former case it is often more economical to use the best coal because, with the higher overload thus made possible, the number of spare boilers can be kept down to a minimum.

It is now almost universal practice to buy fuel on a calorific basis, but it must always be remembered that along with calorific value and analysis there are to be taken into account physical properties. For instance, two samples of coal may show an approximately similar calorific value figure and present wide differences of behaviour in the furnace. Actual boiler tests must therefore be made with sample truckloads of coal if the best and most economical selection is to be made. Anthracite coal with very high calorific value will only burn economically at the rate of 8 to 10 lbs. per square foot. I would certainly not advocate a slavish adoption of the calorific value basis in the purchase of coal for the simple reason that coal is not a manufactured article but a natural product, and if we are to hold the colliery owner or his agent responsible for its calorific value, he will undoubtedly and quite properly, cover himself by increasing the price accordingly; whereas if the coal contractor is not tied down, the customer is sharing the risk inseparable from a natural product. The contractor can be and should be generally tied down to supply from particular pits.

In the Glasgow Corporation Electricity Department the calorific value of the different kinds of coal offered is judged by the previous year's experience, and if any particular kind of coal as delivered is below our previous year's experience of it then that coal has a decreased figure of value allotted to it against the time when next it will be again offered.

A practical test in a boiler specially equipped for the purpose is a very reliable guide to calorific value. The results of such tests should be reduced to a common basis. A good unit of comparison is the cost of evaporation of 1,000 lbs. of water from and at 212° F. or the number of lbs. of water evaporated for a pennyworth of coal, including coal and ash handling, which varies with the quality of the coal. It is usual to express the coal economic result for the whole station in lbs. of coal per kw. hour generated at the switchboard, but as this must obviously vary with the

calorific value of the coal and the steam consumption of the engine or turbine plant, the better unit to use for general comparison is the British Thermal Unit per watt hour, *i.e.*,

$$\frac{\text{lbs. of coal per unit} \times \text{B.Th.U. in coal as fired}}{1{,}000}$$

Even this is not perfect as it does not allow for the variation in load factor between different power stations, but it does enable comparisons to be made irrespective of variations in calorific value. In two of the Victoria Falls power stations the economic result obtained in the way proposed gave in one station 27 B.Th.U.s per watt hour and in another 26. Both of these stations had very high load factors, whereas in many of the London stations, where the lighting load is predominant, the average result is in the neighbourhood of 40 B.Th.U.s per watt hour. Daily samples of coal, as delivered, should be sent to the laboratory of the undertaking for calorific analysis. An assistant, working with a bomb calorimeter, can test twelve samples a day working from 9 to 1 and from 2 to 5 o'clock. These tests are recorded in a coal test book for reference. As the results of tests obtained by any or all of the methods above referred to are tabulated and arranged, an index of the pits in the coalfield, from which the fuel supply is mainly or wholly drawn, can be compiled, and coal prices as received can be equated on a calorific value basis.

An interesting experiment has been carried out in one of the Glasgow Gas Works recently. Gas coke breeze or gas coke riddlings were burned successfully on chain grate stokers with forced draught. A special form of arch had to be built. This breeze can be bought at 20 per cent. the price of coal and it has a calorific value of at least 60 per cent. of coal. There is a large amount of ash, but the experiment went to show that with intelligent superintendence good results could be obtained with this class of fuel, although the actual output of the boiler was considerably reduced.

Boiler-House Staff.

Twenty years ago a fireman in a generating station was truly a fireman. Stripped to the waist, he had in many cases to lift every pound of coal from the floor level to the furnace door. He had to be continually opening and shutting furnace doors and stirring up the fire. At regular intervals he had to bear excessive heat and noxious fumes removing ashes from the furnace which had thereafter to be wheeled away or shovelled direct into carts. It was no uncommon thing in such a boiler-house to have the fireman boasting that he had tackled the load with three boilers whereas he might have saved both labour and fuel by having four boilers going.

All this has been or will soon be changed. The firing of the boiler is now done by operating a rope or a lever. A fire has rarely to be stirred or nursed in any way except by the adjustment of dampers and rate of feed. The substitution of mechanical and electrical machinery for hand labour naturally led to the substitution of the boiler-house engineer for the aforetime fireman. A competent boiler-house engineer is an indispensable adjunct to the boiler-house staff, and the man who knows his business can easily earn the substantial salary which he can command in this capacity. He of course trains his own labourers, but the human element should be and is being cut down as far as possible.

Everything possible should be done to obviate wastage of the heat value of coal in the boiler-house before the steam reaches the turbine. Many opportunities for waste, and consequently opportunities for devising ways and means to avoid waste, are still present in the boiler-house. In the present paper the possibilities of further improvement have been indicated as regards space, material, heat, labour, and time ; and the sum total of the saving which would accrue even from the partial elimination of present waste under these various heads would represent a considerable proportion of the total charges on revenue in a large electricity supply undertaking.

A saving of 1 per cent. in the coal bill of the Glasgow Corporation Electricity Department would this year represent a sum of £2,000.

It is only in recent years that we have come to realise the meaning and the value of a pound better steam consumption in a steam turbine. We now put a money value on steam consumption per $\frac{1}{10}$th of a pound and stipulate for heavy penalties in the event of failure to comply with guaranteed consumption after allowing a tolerance of $2\frac{1}{2}$ per cent. With an equipment such as has just been described, weekly returns can be prepared giving all the particulars any manager wants to satisfy himself that the plant is being properly handled and is doing its work efficiently. Turbine-room data being also available a weekly sheet showing running statistics may be easily made out. A specimen sheet of this kind is annexed (Appendix II.). An exchange of such data between undertakings of about the same size would be mutually beneficial.

Recently in the *New York Electrical World* (April 8th, 1916), a short but exceedingly interesting description was given of methods of handling boilers in a 100,000 kw. station. This referred to the boiler plant in the L. station of the Edison Electric Illuminating Company at South Boston. The editorial referring to the article says: "It is evident in this central station that the electrical end of the establishment has no monopoly of scientific management," and continues that "the liberal use of recording instruments in the steam end of the station and the continuous expert study of operations . . . are all-important factors." The engineer in charge of the boiler-house is expected to maintain the highest efficiency possible with an economical expenditure of time and labour. In this station, containing forty-eight boilers, they have thirty-six steam flow meters, forty draught gauges, two furnace indicators, one CO_2 recorder, two coal scales and one load indicator. In American stations generally considerably more attention is now being given to boiler-house economy, no doubt due to the increasing price of fuel. The workmen in the boiler-house are educated to

interpret the various gauges and recording instruments and encouraged to take an interest in improving conditions. The instruments are not to be erected and stored away in the Chief Engineer's room, but are to be in the boiler-room.

Several very fine records of efficiencies have been attained in America. At the Connors Creek plant of the Detroit Edison Company, which has been in operation for a year, they have two 20,000 kw. turbo-alternators, and each turbine is supplied with steam by two large boilers, each boiler containing 23,500 square feet heating surface. The plant is operating at the present time and producing a kw. hour on 1·42 lbs of coal, *i.e.*, a little less than 20,000 B.T.U.s per kw. hour. This shows an efficiency from coal to electrical energy of 17 per cent. The Chicago Commonwealth Edison Company in their Fiske Street station, have two turbo-alternators of 20,000 to 25,000 kw. capacity. Over a whole year's run the coal used per unit of output was 1·92 lbs., and the average value of the coal as fired was 10,120 B.T.U.s per lb. This gives an average of heating units in the coal as fired per unit of output of 19,450, and also shows a thermal efficiency of some 17 per cent.

The whole subject of fuel economy and the utilisation of coal has been very ably dealt with by Professor Bone in a series of three lectures delivered by him in January and February of this year. The British Association have also formed a Committee to look into the question of Fuel Economy, the said Committee being divided up into sub-committees, one of which is called the Power and Steam Raising Sub-Committee.

If the result of this rapid survey of a number of points in connection with boiler-house design and equipment is a fruitful discussion, the purpose of the paper will have been served.

APPENDIX I.

Test on Steam Pipe Covering.

Elements heated electrically were mounted on insulators and placed inside the pipes, the current to the elements being passed through terminals supported by bushes in the blank flanges.

A thermometer pocket was inserted in the middle of each pipe, the test being to get a comparison of the amount of electrical energy taken by each pipe when the inside temperature of the pipe was kept constant. Care was taken to prevent draughts, the test being taken in a room 10 ft. by 8 ft. by 10 ft. high. Three sets of readings were obtained —one with the temperature inside the pipe at approximately 500° F., the second at 550° F., and the third at 600° F.

The attached sheets give the results of the tests, the last column in each case being the measure of efficiency of the pipe covering expressed in watts dissipated per square centimetre of pipe surface per degree difference. It is undesirable to give a description of the various coverings. Suffice it to say that they include all the best known types and that the test of " A " covering, supplied by Firm IV. proved it to be the best.

The final thickness of the covering in all cases being 2 ins. full.

une, 1914.

Items.	st Year.	Per cent.
A. C. units generated -	329,462	—
D. C. units generated -	518,396	2·9
Total units generated -	847,858	—
Units used in works -	710,983	3·3
Units delivered - -	136,875	—
Maximum A. C. load -	16,100	—
Maximum D. C. load -	3,097	—
Combined maximum load	18,147	—
A. C. load factor - -	35·7	—
D. C. load factor -	5·6	—
Combined load factor -	32·6	—
Plant load factor (engine r	77·0	—
Plant load factor (boiler h	—	—
Coal burnt—tons -	,898·43	—
Lbs. coal per unit generate	3·41	—
Lbs. coal per unit delivere	3·52	—
Average cost of coal per to	11/9·58	—
Total cost of coal -	4 13s. 4d.	—
Cost of coal per unit gener	·2154	—
Cost of coal per unit delive	·2228	—
Average calorific value of	—	—
Average flue temperature	343	—
Average CO_2 - -	—	—
Ashes—tons - -	,191·19	12·9
Turbine vacuum - -	—	—
Barometer - -	—	—

APPENDIX II.

Copy.

PORT DUNDAS STATION RUNNING STATISTICS.

(For week ending May 26th, 1915.)

Items.	This Year.	Per cent.	Last Year.	Per cent.	Totals to Date from 1st June, 1914. This Year.	Per cent.	Last Year.	Per cent.
A. C. units generated	1,170,745	—	979,735	—	61,210,255	—	50,329,462	—
D. C. units generated	546	·04	25,255	2·5	1,562,017	2·5	1,518,396	2·9
Total units generated	1,171,291	—	1,004,990	—	62,772,272	—	51,847,858	—
Units used in works	29,179	2·5	29,682	2·9	1,693,579	2·7	1,710,983	3·3
Units delivered	1,142,112	—	975,308	—	61,078,693	—	51,136,875	—
Maximum A. C. load	15,000	—	11,400	—	19,400	—	16,100	—
Maximum D. C. load	364	—	1,312	—	2,940	—	3,097	—
Combined maximum load	15,000	—	11,400	—	21,762	—	18,147	—
A. C. load factor	46·45	—	51·1	—	36·11	—	35·7	—
D. C. load factor	·82	—	11·4	—	6·09	—	5·6	—
Combined load factor	46·47	—	52·4	—	33·01	—	32·6	—
Plant load factor (engine room)	77·92	—	68·6	—	77·55	—	77·0	—
Plant load factor (boiler house)	65·22	—	—	—	66·71	—	—	—
Coal burnt—tons	1,636·29	—	1,474·68	—	86,405·44	—	78,898·43	—
Lbs. coal per unit generated	3·13	—	3·28	—	3·08	—	3·41	—
Lbs. coal per unit delivered	3·20	—	3·38	—	3·16	—	3·52	—
Average cost of coal per ton	10/3·89	—	11/8·685	—	10/4·84	—	11/9·58	—
Total cost of coal	£844 10s. 11d.	—	£864 7s. 3d.	—	£44,947 6s. 10d.	—	£46,544 13s. 4d.	—
Cost of coal per unit generated	·1730	—	·2064	—	·1718	—	·2154	—
Cost of coal per unit delivered	·1774	—	·2127	—	·1766	—	·2228	—
Average calorific value of coal	11,500	—	11,250	—	—	—	—	—
Average flue temperature base of stack	290	—	311	—	306	—	343	—
Average CO_2	12·0	—	—	—	10·0	—	—	—
Ashes—tons	248·6	15·2	207·05	14·0	12,170·4	14·1	10,191·19	12·9
Turbine vacuum	26·1	—	26·5	—	—	—	—	—
Barometer	30·03	—	30·00	—	—	—	—	—

Summary of Water Meters and Recorders.

Make Up Water, Cooling, and all other purposes. Lbs.	Combined Water. Fed to Boilers. Lbs.	Lbs. Water per lb. Coal.	Lbs. Water per Unit.
11,270,000	24,751,250	6·75	21·15

REPORT ON PIPE COVERING TESTS.

Pipe.	Temperature. Steady F°.	Temperature. Rise F°.	Watts Metre² × F°.
	FIRM I.		
A.	660	568	3·22
	598	512	3·42
	548	468	3·62
B.	670	578	3·18
	610	524	3·38
	558	475	3·55
C.	650	564	3·03
	598	515	3·18
	552	464	3·04
	FIRM II.		
A.	670	573	3·24
	608	514	3·56
	558	468	3·66
B.	665	568	3·32
	590	500	3·69
	541	451	3·80
C.	675	588	3·36
	589	495	3·62
	537	447	3·75
	FIRM III.		
A.	646	555	3·43
	598	508	3·54
	573	486	3·67
B.	661	570	3·34
	618	527	3·53
	551	464	3·75
C.	658	568	3·07
	585	494	3·24
	553	466	3·41
	FIRM IV.		
A.*	317	224	8·05
	302	212	7·95
	280	191	8·14
B.	640	580	2·79
	595	504	2·83
	578	489	2·90
C.	652	559	3·09
	608	518	3·10
	545	456	3·24

* Pipe unlagged.

APPENDIX III.

GLASGOW CORPORATION GENERATING STATION (PORT DUNDAS).

TEST CARRIED OUT ON B. & W. BOILER FITTED WITH SUPERHEATER AND CHAIN GRATE STOKERS. FEBRUARY 26TH, 1914.

Boiler supplied in 1906. Coal used—Scotch Peas.

SUMMARY OF TESTS.

General.	1.	2.
Date of test	Feb. 26th, 1914.	Feb. 27th, 1914.
Duration of test	6 hours.	2 hrs. overload.
Heating surface of boiler	6,182 sq. ft.	6,182 sq. ft.
,, ,, ,, superheater	1,088 sq. ft.	1,088 sq. ft.
Grate area	100 sq. ft.	100 sq. ft.
Ratio Boiler H/S to grate area	61·82/1	61·82/1
Draught used	Induced.	Induced.
Type of stoker	1 style 5 and 1 style 4.	Both grates style 4.
Ground space occupied	350 sq. ft.	
Fuel.		
Kind used	Scotch peas.	Scotch peas.
Calorific value as delivered	10,819 B.T.U.	11,330 B.T.U.
Percentage of moisture	8·35%	13·08%
,, ,, volatile matter	32·23%	37·35%
,, ,, fixed carbon	51·56%	56·72%
,, ,, ash (analysis)	16·21%	5·93%
Total coal fired (wet)	19,300 lbs.	8,300 lbs.
,, ,, (dry)	17,688 ,,	7,214 ,,
Average consumption of coal per hour (wet)	3,217 ,,	4,150 ,,
Average consumption of coal per hour (dry)	2,948 ,,	3,607 ,,
Average consumption of coal per sq. ft. of grate area per hour (wet)	32·17 ,,	41·50 ,,
Average consumption of coal per sq. ft. of grate area per hour (dry)	29·48 ,,	36·07 ,,
Combustible consumed per sq. ft. of grate area per hour	24·70 ,,	33·93 ,,
Total clinker	3,513 ,,	—
Percentage of ash to coal burned	18·20%	—
Combustible	14,821 lbs.	6,786 lbs.

Steam.

Quality	Superheated.	—
Average gauge pressure (lbs. per sq. in.)	188 lbs.	198 lbs.
Average temperature of saturated steam	383° F.	387° F.
Average temperature of superheated steam	561° F	620° F.
Degree of superheat	178° F.	233° F.

Water.

Total water evaporated	146,076 lbs.	64,334 lbs.
Evaporation per hour (tanks)	24,346 ,,	32,167 ,,
Evaporation per hour from and at 212° F.	27,462 ,,	36,928 ,,
Evaporation per sq. ft. H/S per hour actual	3·94 ,,	5·20 ,,
Evaporation per sq. ft. from and at 212° F.	4·44 ,,	5·97, ,,
Evaporation per lb. coal as fired actual	7·56 ,,	7·75 ,,
,, ,, from and at 212° F.	8·53 ,,	8·90 ,,
,, ,, dry coal actual	8·26 ,,	8·92 ,,
,, ,, from and at 212° F.	9·32 ,,	10·24 ,,
Factors of evaporation, including superheater	1·128 ,,	1·148 ,,
*Evaporation per sq. ft of ground space from and at 212° F.	78 ,,	105 ,,

Water Temperature.

Average temperature of feed water entering boiler	248° F.	263° F.

Flue Gas Temperatures.

Average temperature at boiler damper	508° F.	551° F.
Average temperature at economiser outlet	391° F.	395° F.

Draught.

Average draught at boiler damper	15·9 mm.	23·0 mm.
,, ,, at base of chimney	33·7 mm.	36·9 mm.

Flue Gas Analysis.

Average percentage of CO_2	11·8%	10·9%
,, ,, ,, O	7·3%	—
,, ,, ,, CO	Nil.	—

* If space occupied by economiser is added, these figures are reduced to 40 and 53 lbs. per square foot of ground space.

Furnace.

Average thickness of left hand fire -	$5\frac{3}{4}$ ins.	5 ins.
,, ,, ,, right hand fire -	$4\frac{1}{2}$ ins.	4 ins.
Speed of left hand grate - - -	2 and 3.	2, 3, and 4.
,, right hand grate - - -	1, 2, and 3.	3 and 4.
Average ft. per hour : Left hand grate	17·3 ft.	21·4 ft.
,, ,, ,, Right hand grate	14·3 ft.	22·8 ft.
Temperature of boiler-house near grate	71° F	71° F.

Efficiency.

Combined efficiency of boiler and superheater - - - - - -	76·23%	75·87%

Heat Balance.

Heat absorbed by boiler and superheater - - - - - -	76·23%	75·87%
Heat carried away in gases leaving boiler - - - - - -	12·96%	15·41%
Loss due to radiation and unaccounted for - - - - - - -	10·81%	8·72%
	100·00	100·00

APPENDIX IV.

TESTS ON A MODERN BOILER FITTED WITH OVERHEAD ECONOMISER.

(Supplied 1915.)

Boiler.

1.	Type	Water tube.
2.	Heating surface	4,081 sq. ft.

Superheater.

3.	Type	Integral.
4.	Heating surface	1,460 sq. ft.

Economiser.

5.	Type	Steel tube.
6.	Heating surface	3,080 sq. ft.

Stokers.

7.	Type	Chain grate.
8.	Grate area	144 sq. ft.

Draught Plant.

9.	Type	Cold Air Ejector.
10.	Height of chimney from firing level	77 ft.

Ratios.

11.	Boiler heating surface to grate area	28·3/1
12.	Boiler and economiser heating surface to grate area	50·2/1
13.	Economiser heating surface to boiler heating surface	77·3%

Complete Unit.

14.	Total heating surface (boiler, superheater, and economiser)	8,621 sq. ft.
15.	Total ground space occupied	383 sq. ft.

General.

16.	Date of test	Jan. 7th, 1916.	Jan. 7th, 1916.
17.	Duty	Normal load.	Overload.
18.	Duration	5 hrs. 8½ mins.	1 hr. 30 mins.

Fuel.

19.	Kind used	Washed nuts.	
20.	Analysis: Volatile matter	28·75%	
	Fixed carbon	67·25%	
	Absolute ash	4·00%	
		100·00%	
	Moisture	4·61%	
21.	Gross calorific value of dried fuel	14,209 B.T.U.s.	
22.	Gross calorific value of dried fuel as delivered	13,554 B.T.U.s.	
23.	Nett calorific value of fuel as delivered	13,045 B.T.U.s.	
24.	Total quantity fired	18,401 lbs.	5,687 lbs.
25.	Coal consumed per hour	3,080 ,,	3,791 ,,
26.	Coal consumed per sq. ft. of grate per hour	21·4 ,,	26·3 ,,

Steam.

27.	Average gauge pressure	165 ,,	166 ,,
28.	Saturated steam temperature	372° F.	372° F.
29.	Superheated steam temperature	673° F.	689° F.
30.	Degree of superheat	301° F.	317° F.

Water.

31.	Temperature entering economiser	93° F.	93° F.
	,, leaving economiser	183° F.	180° F.
33.	Total quantity evaporated	162,624 lbs.	49,610 lbs.
34.	Evaporation per hour actual	27,218 ,,	33,073 ,,
35.	Equivalent evaporation per hour from and at 212° F.	36,608 ,,	44,781 lbs.
36.	Evaporation per lb. coal, actual	8·84 ,,	8·72 ,,
37.	Evaporation per lb. coal from and at 212° F.	11,89 ,,	11·81 ,,
38.	Evaporation per sq. ft. of boiler heating surface, actual	6·67 ,,	8·10 ,,
38a.	Evaporation per sq. ft. of ground space from and at 212° F.	95·6 ,,	116·9 ,,

Factors of Evaporation.

39.	Boiler and superheater	1·252	1·265
40.	Boiler, superheater, and economiser	1·345	1·354

Draught.

41.	Kind	Ejector.	Ejector.
42.	Suction at economiser outlet	·55 in.	·8 in.
43.	Power taken to produce draught	7·6 kw. = 9·2 B.H.P.	13·8 kw. = 16·6 B.H.P.
44.	Equivalent in steam consumption per hour (assuming 15·4 lbs. per kw.)	117 lbs.	213 lbs.
45.	Percentage of steam generated	·43%	·64%

Flue Gases.

46. Temperature entering economiser -	577° F.	624° F.
47. ,, leaving economiser -	386° F.	419° F.
48. Average CO_2 - - - - -	12·4%	12·9%

Heat Balance.

49. Efficiency of boiler, superheater, and economiser (based on gross calorific value of fuel) - -	85·09%	84·49%
50. Heat carried away in flue gases -	9·20%	9·72%
51. Heat lost in radiation and unaccounted for - - -	5·71%	5·79%
	100·00	100·00
52. Overall efficiency, based on nett calorific value - - -	88·41%	87·79 %

DISCUSSION.

Mr. S. E. Fedden (Past President) (Chief Electrical Engineer, Sheffield) said Mr. Lackie's very practical paper dealt with a subject which interested him two years ago when he read his paper at Coventry, although at the time he had no idea that a war would soon make him lay down something like 40,000 kw. of boiler plant. The subject was particularly interesting to him now because he was laying down another big power house which he hoped would be designed for no less than 100,000 kw. Mr. Lackie said that the main object is to have the maximum steaming capacity in the minimum of space, but he hardly agreed with that. The first thing to be considered was the load factor the power house was to be run at. In the old days plants were laid down for 25 per cent., 30 per cent., and 40 per cent. load factor, and on the North-East coast for as much as 70 per cent. load factor. The load factor should be that upon which the station would be run in the future, and not at present, and on it depended how much coal and ash would have to be dealt with. In his opinion the important consideration in boiler-house design was how they were going to get in the coal, say, for a 100,000 kw. station. Depending on the load factor, this coal would vary from ten to fifteen thousand tons per week, and consequently the amount of ash would vary from 10 to 25 per cent. Then came the question of coal storage, because railway facilities would be required for dealing with 100,000 or 150,000 tons of coal. Thus it would be necessary to consider the point that if development was to take place on the basis of a 70 per cent. load factor, would the capital expenditure on the present lower load kill it? Against that there was the possibility that if he laid down plant for a 40 per cent. load factor, probably in ten or twelve years' time the load would swamp him, in that he would not have the capacity to get in coal or take away the ashes. Therefore it was wise to buy the few acres extra of land to enable this to be done. Personally, he thought the boiler-house now was a more important place than the turbine-house, and from the experience he had lately had in a big boiler-house, he had started an engineer to watch the boilers solely. This man had nothing whatever to do with the turbine-house, and from further experience it might be advisable later on to have a sort of shift engineer or foreman to do nothing but watch the dumping of the ashes. With regard to riddlings and the calorific value to be obtained from them, this depended a great deal upon whether the

grate was well covered or whether the fuel burned off before reaching the dumping bars, so that there was only ash on the latter part of the grate. He had taken out some figures showing that on a well covered chain grate the riddlings contained 9,596 B.Th.U., whilst on a grate that was only half covered the value was 6,066 B.Th.U. In connection with this, Mr. Lackie spoke of the CO_2 obtained. This depended altogether again as to how far the grate was covered. Mr. Lackie had taken an average of 11 per cent. for the year, but he (Mr. Fedden) was totally unable, whatever he did, unless he wasted an enormous amount of coal in dumping, to obtain more than about 8 to 9 per cent. of CO_2, and the majority of the stations in the country he did not believe were run on much more. The possibility was also mentioned of having CO, but he did not think there would be much CO formed unless there was 13 or 14 per cent. of CO_2; but he was perfectly certain that if they ran at 14 per cent. CO_2 there would be no boiler arches or brickwork left at all. As to steam flow meters, he had been unable to find a satisfactory one. He put one in which did not register correctly, and the makers said various things were wrong, but although he took into consideration the fact that it was war time he had not been able to get satisfaction after a one or two years' negotiation. At Coventry he had discussed the problem of stokers, whether he should put in a chain grate or Underfeed or Riley's or any other stoker, and he decided to divide them, and try to learn something about them in actual use. He was now able to give a few figures on this subject relating to high calorific and low calorific coal. Taking chain grates that were burning high calorific singles 14,000 B.Th.U., with only 5 to 6 per cent. of ash, and burning 25,000 tons of coal, the cost of maintenance was 2·72d. per ton. Burning a low calorific coal 10,000 to 11,000 B.Th.U., with from 10 to 20 per cent. of ash, and burning 37,000 tons of coal, the maintenance of the chain grate was 0·46d. per ton. Thus it would be seen there was a very great difference in the upkeep of chain grates according to the fuel they burned. They did not like a high calorific value fuel. The Underfeed stokers, which were very useful for rushing up a sudden load, which could not be done with the chain grate, showed that burning 53,000 tons the upkeep was 0·57d. per ton, but that figure would rise if much banking had to be done, and especially if there was much unskilled labour employed to look after the grates, because in banking an Underfeed stoker, if the live fire was not taken off the bars and put on the side dumping plates and the bars covered

with green fuel, a set of bars would be ruined in a night, and the saving in this respect would pay for skilled men. On the same question of maintenance he had some figures of a bucket conveyor. With the conveyor which was taking washed coal the maintenance was 1·18d. per ton handled, but the moment coal that was not washed was put on that conveyor the maintenance quickly rose. With a similar conveyor handling the ashes the maintenance was no less than 17·76d. per ton handled, and he had hopes that the suction plant, notwithstanding its absurd capital expenditure—the makers were charging twice what they ought to do, and were making 200 to 300 per cent. profit on the cast-iron pipes—he believed that from the point of view of maintenance alone they would pay to put in. The question of unburned coal was mentioned by Mr. Lackie, and this touched upon the point he had already mentioned of it paying to keep a man in the ashes trench. He had a serious fire in his ashes heap some time ago, which burned for a long time and cost a lot of money to extinguish. This led him to investigate the unburned coal that was being taken out from the ashes trench, and tests showed that the material turned out of the ashes trench contained 4,646 B.Th.U. This was due either to carelessness in dumping too much unburned fuel or by trying to get a higher CO_2 and a heavily covered fire right to the end. He told his boiler-house engineer that it must be reduced, and it had been reduced by 25 per cent. In other words, the ashes had now only 3,152 B.Th.U. on an average. With a 100,000 kw. station consuming £12,000 of coal per week this obviously meant a saving of £600 to £700, and a saving of that description easily paid for the salary of the man over and over again. Later on Mr. Lackie stated that having ascertained the amount of coal used and having measured the condensate, it was possible to get the amount of water evaporated per pound of coal used. He did not think this was so, because between the boiler and the turbine there were a number of losses. He certainly would not put down boilers simply to supply the condensate for the turbines, and to get at the results he had put in a Lea recorder on the feed tanks, and measured all the water coming into the boilers, not just what came from the condensate, and thus he got a separate check. He found that he had to supply something like 15 to 20 per cent. more steam than was actually got from the condensate from the turbines. As to losses in radiation, he had started out to find some of these unaccountable losses which Mr. Lackie put at 6.5 per cent. in the paper, although in the last schedule he had

taken 10 per cent. He had found, for instance, that the soot in the boilers accounted for one or two per cent. of these losses, and it was rather interesting to find the difference of fixed carbon ash and the calorific value in the different banks of boilers. In the front bank the soot calorific value was 694 B.Th.U., in the superheater it was 1,232, and in the back chamber it was 3,430. In the front economiser it was 2,970, and in the back economiser the calorific value in the soot was 3,320 B.Th.U., which all went to make up a percentage of the unaccounted for losses. It was suggested by the author that daily samples of coal should be taken to the laboratory, but when dealing with 4,000 or 5,000 tons of coal a week it would need a great many chemists to take these samples and test them. He took samples from each of the hoppers every day, collected them, and made a final test once a week. Another interesting point was the increase of ash in coal since the war. From one colliery the calorific value since the war began had decreased from 11,700 B.Th.U. to 9,700 B.Th.U., whilst the ash had increased from 10 to 25 per cent. From another colliery the calorific value had decreased from 11,000 to 9,800 B.Th.U. and the ash had increased from 11 to 20 per cent. Apparently at the present time they had to take what they could get, and be very pleased to pay for it. Another point worth mentioning was the lack of scientific knowledge of the colliery staffs. The representative of one colliery with whom he was negotiating for 20,000 tons said he knew nothing whatever about calorific value and did not wish to talk about the theory of coal. Mr. Lackie seemed to have overlooked the use of the pyrometer for testing the exhaust gases from the boiler. This was a better guide than a draught gauge as the temperature gradually increased from week to week as the boiler got dirty. Perhaps, however, a draught gauge, and a pyrometer would be more useful than one or the other. He did not altogether accept the wonderful results from American stations which were mentioned in the paper. As to the efficiency of pipe covering, there was a distinct improvement in heat insulation as between a bright surface and a dull one, and it seemed to be the same principle as the Berry "Tricity" Cooker that with a bright surface the heat was conserved very much more. With regard to the boiler tests referred to in the paper, no mention was made as to whether the boilers were in the same condition, but it would seem that the lower efficiency of the old boiler was owing to radiation losses. Altogether, he did not think these tests were quite comparable.

Mr. J. Christie (Past President) (Chief Electrical Engineer, Brighton) said there was one strong point that Mr. Lackie had omitted to refer to, and one which must have a most important bearing on the general design, lay-out and operation of boiler-houses such as will be necessary to deal with the "super-stations" which they hoped to see dotted about the country in the near future in connection with the universal supply of electricity. He referred to the question of firing boilers by means of gas instead of coal. Dr. Ferranti—and all credit was due to him—dealt most fully with this subject some years ago, and it had since been referred to by many other "disciples of progress," both in papers and articles in the lay and technical Press, but so far with little practical result. The colossal power plants of the future with extra high tension transmission must be located on suitable sites outside their areas of supply where land was comparatively cheap, but with the large size turbine units which it would then be standard practice to install, the difficulty would be to find accommodation to house the steam-raising plant within a reasonable radius of the unit which it had to operate, and this would become more and more acute as their size increased, chiefly due to the large proportion of the total cubical capacity of the space available for housing the boilers, which, under present conditions, had to be allocated to coal storage, coal and ash handling plant, automatic stokers, etc., as distinct from the actual boilers themselves. Why not face this problem boldly by altering the fuel supply system, with all its attendant disadvantages right away from the power house proper, and on some suitable adjoining site provide coal stores, retort houses, and recovery plant for carbonising the coal on the low temperature process, thus extracting its maximum value, and lead the resultant gas as the fuel supply to the power house by pipe lines? Greatly increased boiler capacity could then be installed per square foot of floor space. This could be housed in cheap, light, airy buildings; all dust, dirt, soot and ash incidental to coal firing would be entirely done away with, and due to the clean surface and simplicity of regulation the maximum duty from the boilers could be continuously obtained with a minimum of labour, supervision and standby loss. Such an arrangement would provide an adequate supply of coalite for use as fuel to meet all industrial and domestic requirements, thus solving the smoke problem in our large cities, and by the recovery of the rich tar, sulphate of ammonia, toluol, benzol, and other valuable residuals which are at present wasted, enable us in this way to foster new

chemical industries in our own country, to supply products for which, before the war, we were almost entirely dependent on Germany and other sources abroad. During the last few months he had had occasion to go into such a proposition on quite a modest scale for use in conjunction with their own works, and he felt so confident of its ultimate success that he was now most strongly urging his Committee to complete negotiations with the British Coalite Co., who proposed to co-operate with them in the scheme, to establish a plant capable of carbonising in the first instance some 200 tons of coal per day, and from that he hoped to generate by means of the residual gas which they would contract to purchase on most favourable terms, approximately 30,000 units per day at little more than half the corresponding cost for coal, and in his opinion the larger the scheme and the higher the load factor, the greater would be the prospects of success for such a combination as he had attempted to outline.

Mr. S. L. Pearce (Past President) (Chief Electrical Engineer, Manchester) associated himself with the remarks of the previous speakers with regard to the value of the paper. Mr. Lackie had been fortunate in that he had paid at least one visit to America, and had been able to see what was being done there, and no doubt many of the views expressed in the paper had been to some extent prompted by what Mr. Lackie saw in the States. With regard to the axiom that the main object of a boiler-house is to have the maximum steaming capacity in the minimum space, he felt with Mr. Fedden that this was not the sole criterion. Doubtless, under present-day conditions, engineers were trying to cram as much steam raising plant as possible into existing buildings. In order to provide sufficient steam for the large turbo-alternators now being installed in existing engine rooms it was necessary to get the last ounce out of the boiler-house. Looking at the problem *de novo* the question of getting the maximum steaming capacity into the minimum space was not the sole criterion, and that brought him to the question of the two-story *versus* the three-story boiler-house. The author stated that there was a limit to the maximum output per square foot of grate area, and put it at about 100 lbs. per square foot. Starting from that point, the sole consideration whether the economisers should go above the boilers or whether they should be on the same plane as the boilers, resolved itself into a question of the relative space required for the boiler-house and the engine-room respectively.

In connection with the proposed Barton station of the Manchester Corporation he had considered this point in very great detail, and had arranged the economisers behind the boilers A boiler-house of this construction, owing to the lighter steel structural work, and despite the fact that additional ground space was required, showed a saving of about £8,000 over the triple-story building, or, expressed as a percentage, such a boiler-house could be erected at a cost of about 20 per cent. less than the three-story arrangement. Mr. Lackie quite rightly emphasised the question of having a clean and light boiler-house. He had seen numerous stations with the economisers above the boilers, but he had not yet seen one in which there was a reasonable amount of natural light, and he failed to see how they were going to get it with such an arrangement. With the Barton arrangement it was obvious that all the light that was necessary could be obtained from the roof lights. This question was also bound up with the type of chimney used. With the arrangement of one chimney per boiler, or one steel chimney and induced draught plant for every two boilers, an enormous amount of grit was emitted from the chimneys, which, falling on the roof lights, obscured them. Mr. Lackie might reply that that was all right so far as it went, but it was necessary to get in all the boiler plant corresponding to the turbine-room. At Barton he had been able to do this with the two-story arrangement, the over-all width of the four boiler-houses corresponding with the length of the turbine-room which was designed for 160,000 kw. He failed to see any advantage in adopting the overhead economiser arrangement, because it simply meant that with a lesser width of boiler-house there would be a space between the various boiler-houses of insufficient width to be of any practical use whatever. The author stated that modern turbine-rooms could accommodate twenty horse-power per square foot of engine-room floor, but this appeared to him an excessive figure. At Barton he had about ten, and that value would hold good for units of 20,000 kw. It was possible, of course, to get a higher figure so far as the actual engine-room floor space was concerned, but the deciding criterion was the basement space to take the condensing plant, pumps, and pipe work. This decided the centres at which the main units could be fixed. He did not think Mr. Lackie intended, as Mr. Fedden had suggested, that the riddlings and ashes were conveyed up into the bunkers again and sent down indiscriminately on to the various boilers. It was an excellent plan to devote one or two boilers in a boiler-room for the purpose of dealing with

riddlings and ashes, but to do as Mr. Fedden had suggested he did not think was quite what Mr. Lackie intended. In dealing with the case of a boiler-house to supply steam to two 15,000 kw. sets, Mr. Lackie stated that the steam required for each would be between 180,000 and 200,000 lbs. of superheated steam per hour. Where did he get his reserve plant from in this case? With these super-stations of the future working at high load factors it was absolutely essential to have a very big reserve, not only in the aggregate steam available, but also in the boiler units themselves. The author gave an alternative arrangement for a boiler-house with the firing from two sides, but he did not think it had anything to commend it. The side wall lighting was bound to be inefficient, and it was more expensive, because this plan involved an additional set of coal bunkers per boiler-house, and the modification of that scheme which had been adopted in many American stations where the boilers were fired from both ends with one coal bunker above seemed preferable. Like Mr. Fedden, he was still looking for a steam flow meter, and at present it seemed as if the words "steam meter" were a synonym for inaccuracy. Mr. Lackie's proposed steam pipe arrangement hardly seemed necessary, even with boilers of 50,000 to 60,000 lbs., for it would certainly increase the radiation losses without, so far as he could gather, any corresponding advantage. The tentative arrangement at Barton of the coal handling plant provided for a very liberal use of the coal conveyers, and he was glad to have Mr. Lackie's assurance that he considered coal conveying plant was likely to work out the cheapest. Another point to be emphasised was the question of the dividing up of the coal bunkers in the boiler-house as much as possible so as to avoid fires. A further point was the tendency in many power stations in this country to neglect the boiler feed pumps. They were stuck away anywhere, and he had been very much impressed by the arrangement that was adopted in the new Paris station. The pump hall was situated between the turbine-room and the boiler-house, and on the floor of the hall would be placed the centrifugally driven feed pumps. He disagreed with the author in his apparent preference for the reciprocating type of pump. As regarded over-all efficiency the latter could not compare with the centrifugal, and as regards maintenance his experience had been that the centrifugal pump was by far the most satisfactory. As to ash handling it was very important that provision should be made to remove the ashes by rail, road, or water. That had been done at Barton. Incidentally, the ashes should be kept

separate from the soot. Ashes might have a market, and soot might have a market, but the two mixed together had no market. Mr. Pearce showed a table which brought out the comparative difference between what might be termed American practice, and possibly representative British practice.

DETAILS OF SOME LARGE WATER TUBE BOILERS.

	Detroit.	Chicago.	Manchester.
Heating surface in square feet -	23,630	12,250	11,500
Economiser surface in square feet	None	8,500	5,000
Superheater surface in square feet	—	612	3,924
Grate area in square feet - -	400	274	312
Evaporation in pounds per hour -	130,000	70,000	50/60,000
Consumption of fuel per square foot of grate area per hour -	—	45 lbs.	21·25 lbs.
Gauge pressure in pounds per square inch - - - - -	200	210	225
Superheat - - - - -	—	225° F.	275° F.
Diameter tubes - - - -	4 inches	4 inches	3–15/16
Water evaporated per hour per square foot of heating surface -	5·64	6·53	4·75
B.H.S./G.A. - - - -	59/1	44/1	35/1
Temperature of feed water - -	—	250° F.	210° F.

Special attention might be drawn to the economiser surface and the superheater surface provided in relation to the heating surface. Then there was the comparatively small grate area in the case of Chicago. The evaporation in pounds per hour was larger, but he had not the slightest doubt but that the Manchester boilers would do considerably more than the figures given. Consumption of coal per square foot of grate area per hour in Manchester was purposely low in view of the long hours of operation contemplated. Similarly in the ratio of boiler heating surface to grate area the Manchester figures were low, and summing up the results, one might say that British practice erred very much more on the safe side than American practice. The boilers were designed for long continued operation with a fairly big margin. Several of the high figures often quoted in the case of American boilers were, he believed, obtained with one or other form of the Underfeed type of stoker working with forced draught.

Mr. John Roberts (Durban) said that the scale of operations in many of the provincial towns of South Africa did not place him in the position to offer criticism of such schemes as had been under discussion. He expressed his appreciation of the invitation to be present at the meeting, particularly in view of the fact that he happened to have been responsible for setting in motion a movement to form a similar association in South Africa. Last September a meeting of central station engineers from various parts of South Africa was held in Johannesburg. The proceedings lasted six days, and the expression of opinion was made several times that perhaps some day or other the South African Association might become incorporated or affiliated with the Incorporated Municipal Electrical Association. That expression of feeling he now wished to emphasise, having regard to the very great assistance and courtesy that he had received during his visit here. Sentiment played a greater part in the distant parts of the British Empire than many might perhaps think, and the electrical engineer in South Africa, for instance, would go to some extremes to have British plant rather than American or any other. As regards the paper, he had had a little experience in Durban of large boilers, although, in saying this, he was not speaking of designs for superstations but of stations having a moderate capacity, such as he hoped shortly to have in Durban, containing from 20,000 to 30,000 kw. of plant. Probably sufficient stress had not been laid on the very great importance of simplicity in the boiler-room, which was now afforded by the boiler developed by a large manufacturer, in which the grate, the boiler itself, the economiser, the chimney, and everything was all self-contained and placed on one foundation similar to a turbine, and that improvement seemed to him to be as noteworthy in boiler engineering as had been the introduction of the steam turbine in engine-rooms.

Mr. David Wilson (Messrs. Babcock & Wilcox) said that the chief point in Mr. Lackie's paper was the suggestion that future boiler design must be in the direction of increased evaporation and reduced ground space. There was considerable difference of opinion as to the maximum rate per square foot of heating surface. It was recognised that boilers working at very high rates of evaporation required more scientific attention, and it was also essential that every care should be given to the feed-water to prevent scale or oil getting into it. As a matter of fact, some of the continental stations had put down distilling plants for dealing with the make-up water, whilst at others—for instance,

at Amsterdam—they used only condensate for the high duty boilers, pumping all the make-up into some old cylindrical boilers. There was something to be said for this system because it practically dispensed with the necessity for blowing down the boilers, and the make-up was reduced to a minimum. The disadvantage of the system was the possibility of corrosion. He was glad Mr. Lackie had translated the fundamental principles of boiler design into such simple language, because even now a good deal of commercial talk was heard about one design of boiler being able to evaporate much more than another. The correct efficiency of any of the established boilers was now fairly well settled, and the output became largely a combustion factor. Whilst the evaporation per square foot of ground space was influenced to a certain extent by design, depending upon the amount of heating and recuperating surface which could be placed *directly* over the grate area, the selection of furnace was determined very largely by an engineer's preference for forced or induced draught. He was inclined to agree with Mr. Lackie that with a normal coal market it did not pay to burn very low-grade fuel, unless the geographical position of the power-station was very favourably placed relative to the coal fields. It was quite possible to obtain, on test, high thermal efficiencies and output with low-grade fuel, but to obtain these figures in ordinary practice required much more supervision of the stokers than when burning high-grade coal and, depending upon the amount of supervision given, the economic results could vary very considerably over a month's run. Some of the highest over-all efficiencies were obtained in stations using high-grade fuel. For instance, at the Detroit Station there was an efficiency of 17 per cent. with coal of a value of 13,000 B.Th.U. At the Hague Works the efficiency was between 15 and 16 per cent. with a similar coal, whilst at Rotterdam, Amsterdam, and Dordrecht, they were getting about the same figure. Against this, at Dunston they were getting 15 per cent. with coal of only 10,000 B.Th.U., whilst the Victoria Falls Power Company, producing two million units per day, obtained 13 per cent. efficiency with coal of only 10,000 B.Th.U. A large percentage of the coal used by this company indeed was only 7,500 B.Th.U., used in conjunction with fairly high induced draught, but the latter stations were favoured with high load factors. The paper referred to a result of 9 to 10 lbs. per square foot of grate area burning anthracite, but he took it this was a pure anthracite, burned in hand-fired furnace, because it was now possible for low volatile fuels to burn up to 25 or 30 lbs. on mechanical stokers. In con-

clusion, he reminded the members that boiler makers were not sitting still, and it would impress many of them if they knew the amount of investigation work that was being done. In spite of the present coal restrictions the water-tube boiler was doing its bit in the direction of improved fuel economy, and if we all confine ourselves to only reliable and accurate comparisons the ultimate result should be a further advance by all boiler and stoker contractors.

Mr. C. H. Wordingham (Past President) agreed that the conclusions arrived at in the paper were generally sound, and he felt some sympathy for the author in the way his statement as to the main object in designing a modern boiler-house being to have the maximum of steaming capacity in the minimum of space had been seized on by several speakers who, however, had lost sight of the beginning of the sentence, namely, that "many considerations have now to be kept in view in the design of a modern boiler-house but——" The author did not by any means imply that that was the only consideration. He himself had occasion some sixteen years ago to consider the design of what was at that time a very large station, namely, 50,000 kw., and he claimed to be one of the early advocates and users of large units as they then existed. In connection with this design he was driven to the same conclusions as Mr. Lackie, namely, that it was of vital importance to get a compact boiler-house if they were to have large generating units. One thing Mr. Lackie had omitted to give much attention to, and that was the steam pipe arrangements. With these large boiler-houses at right angles to the engine-room, the difficulties introduced by expansion and radiation losses were really very great, and they called for great care in design. He was much interested in the author's tests of various boiler-covering materials, and the question of heat insulation was one which had not been adequately realised by central-station engineers. The figures were striking as they showed a difference between the worst and best materials of some 20 per cent., and there was no need to labour the importance of such a difference in radiation losses. He was a little doubtful whether it was wise to specify the thickness of the insulating coverings because, as the over-all diameter was increased, the radiating surface was increased, and with some coverings it might be a question as to whether more was lost than gained by so doing. Therefore, if Mr. Lackie could have extended his experiments to different thicknesses of the same coverings, he would have added greatly to their knowledge. In connection with the

compactness of boiler-houses necessitated by large units, might he suggest whether it was wise to go to such enormous sizes of turbo-generator units as were talked about in America, namely, 50,000 kw., and even 100,000 kw. he believed had been spoken of. Was there really any gain in going to such sizes which involved such great difficulties in the boiler-house ? Mr. Christie had spoken of gas fired boilers, and that was another matter he had gone very carefully into sixteen years ago. From the information he got then he found it was absolutely hopeless to attempt to compete with coal firing. Since then very great improvements had been made in the Bonecourt system of surface combustion, and recovery plants had been developed, and therefore he thought there was a great future on the lines Mr. Christie had mentioned. This pointed to a combination of the interests of the gas and electrical industries. That was a matter which he had strongly advocated in the past with, he was afraid, a great deal of unpopularity, but it must not be forgotten that keen as electrical engineers were on producing electrical energy cheaply, gas engineers were equally keen upon gasifying coal in the most economical manner, and in any future developments on these lines gas engineers must come in.

Mr. W. M. Selvey (Sheffield) said he proposed to touch on one or two points in the paper, and then to offer a few observations on general questions relating to fuel and its utilisation. He thought Mr. Lackie's paper had touched on practically all the live questions which were being considered in connection with the new large power stations which were being constructed. Looking ahead he was rather struck with the author's idea that there was any necessary connection between the space devoted to boilers and the space devoted to turbines, which was, he thought, a purely conventional one. It was evident that the design of the boiler-house was now the main feature of the power station, and that the engine-room was only a small annexe. The movement towards remote control which would separate switch-gear entirely from the engine-room made this annexe even more insignificant. It was very possible that they might return to the long, narrow turbine engine-rooms of the earlier American design. Mr. Lackie had pointed out that the annexe to the boiler-house in the way of railway sidings was a very large item, and had much weight in determining a suitable site. He would suggest also that in addition to that that the areas for coal storage and, in some cases, for cooling towers were very large items. All these things tend to make the question of

the engine-room relatively insignificant, and the space which would be available in it was so large that the whole of the auxiliary machinery, including even feed pumps, would be placed together in the engine-room under the one crane. It would be seen that the factors to consider in their future stations would be ample land, *i.e.*, cheap land, and ample water supply. Mr. Lackie had really dealt with the refinements which could be effected at the present time in the next step from already highly efficient boiler-houses. Based on the figures for per cent. CO_2 and flue gas temperatures, he had analysed the test results given and gave the following as in his opinion the true efficiencies within 2 per cent.

	Case 1.		Case 2.	
Gases leaving Boiler - -	508° F.	551° F.	577° F.	624° F.
,, ,, Economiser -	391° F.	395° F.	386° F.	419° F.
Per cent. CO_2 in Flue Gases	11·8%	10·9%	12·4%	12·9%
Extracted by Boiler - -	77·7	75·3	76·3	75·6
Extracted by Economiser -	3·6	5·1	5·4	5·6
Total Efficiency - -	81·3	80·4	81·7	81·2
Flue Losses - - -	13·7	14·6	13·3	13·8
Radiation and unburnt Fuel	5·0	5·0	5·0	5·0
	100·0	100·0	100·0	100·0

He could see no hint that Mr. Lackie was looking forward to any changes which may ultimately come about when the electricity undertakings were the biggest coal consuming concerns in the community. He proposed to remark on this again when he came to the question of fuel. Mr. Lackie had referred to the proportion of grate area per square foot of boiler-house space. The marine boiler design of Messrs. Babcock & Wilcox lent itself very much to effective use in that direction, but their other successful boiler builders in this country had not properly tackled this question. Those who had read the account of Dr. Jacobus' tests on the boilers at Detroit would have seen how in the States they have utilised the good features of the Stirling boiler by turning a pair through 90° and placing them front to front, thus making something very like the outline of a Yarrow boiler with the addition of right and left-hand drums at the top with nests of tubes connecting them to the bottom drum. By means of this design the only part which is taken up of the floor area is that of the two bottom drums which run parallel to the boiler sides. He somewhat wondered why this scheme had not been put forward by makers of vertical tube boilers. There was no reason why any of those boilers could not

be thus modified and very much greater output per square foot of boiler-room floor obtained. The four-drum Stirling was the most forward in that respect. As a practical fireman he was of the opinion that it was a great mistake to cut down the alleys between the boilers or, what would be in some modified types, the platform at the back of the boiler. He was not enamoured with the idea of elevating riddlings to the coal bunkers except to some special hopper at the end of the station, from which such stuff could be drawn for banking boilers or for combustion into some specially allocated boiler. This question of riddlings was of much more importance with the old open link grates, but now with close link grates the amount dropped was exceedingly small, and was largely mixed with ash. Mr. Lackie had passed over the question of stokers. He touched on that question when he had the pleasure of speaking on Mr. Fedden's paper at Coventry in 1914. Since that time quite a number of experimental stokers had been in service long enough to accumulate considerable experience. The idea of the travelling band of a thoroughly mechanical construction with fire bars mounted on it which take no strain but only act as a platform for the coal, was gradually gaining ground. Attempts to do away with the travelling grate type of stoker had in the end resulted in an appreciation of its good points, and in a return to the idea, but with considerable advance in construction. There were much greater efforts being made to run fire bars easily replaceable either by means of some such scheme as the drop link where a single small bar can be slipped on or by designing a cage of bars whereby they are bolted on a dozen at a time. The difficulty with all such schemes appeared to be that any extremity in bar or cage which was not massive in metal sooner or later would burn or swell and fracture. Hence the old type of link grate was still holding its own in competition with these newer forms. The links were now so much more accurately machine-moulded that the mechanical friction of the grate was very much less, and broken links, which were so awkward to replace, were becoming much less common. The movement in American stokers was, he thought, quite unsuited to British coal, and his opinion was still what it had been for four or five years past, namely, that they wanted emergency travel rates on the ordinary chain grate two or three times as fast as was then the case. Thickening up a fire was not the correct way to produce rapid combustion. It necessitated much more draught on the grate than the thinner fire run faster, it gave rise to much higher internal temperatures in the fuel. This was more likely to cause burnt links, it facilitated the formation

of fluid clinker, and, lastly, the high draught necessitated had a great tendency to lift ash both solid and fluid upon and among the tubes. The mechanical improvements in chain grates would render this emergency speed much more possible. It would have been impracticable with the older type of grates. These suffered very severely from temperature effects under overload conditions, and the driving power became not only excessive, but the grates used to stick altogether. Another objection to getting heavy overload out of a boiler by thick fires was that it was almost impossible to check such fires when once well alight. Thus these boilers could only be taken off very gently, or they got a bad recurrence of the old smoke nuisance. Mr. Lackie stated that the output of the boiler depends on the grate area. This statement wants a little explanation, because it might be argued to read that if one doubled the grate area of the boiler they would double the output, which of course was not at all so. If a boiler was worked on the full available draught, the doubled grate area would make practically no difference to the output. On the other hand, if a boiler gave its output with a considerable margin of draught, considerable increase could be obtained from a larger grate. There was conflict for draught between grate friction and tube friction, and while tube friction went up practically as the square of the total gases passing, the grate friction went up much more rapidly, owing, as before mentioned, to the overloads being taken on thicker fires. Presumably with the same thickness of fire running faster the proportion of draught used in these two elements would remain about constant. With regard to the larger question of fuel, Mr. Lackie had only dealt, as he had said before, with the refinement of the present coal-fired station. Since the war, however, what had touched the public mind most had been the question of by-products from coal, and thereby the consumption in the power station of coke. While a good deal of uninstructed information was being volunteered in various quarters, the fact remains that in the future the electrical industry would be the biggest coal buyer and coal user. With such large capital employed sooner or later the industry must accumulate large reserve funds, part of which must be allocated for investigation and research in exactly the same way as was necessary in a manufacturing concern. He thought the time was rapidly approaching when the electrical power manufacturer would no longer be justified in looking to the manufacturer of mechanical and electrical apparatus for all investigation work and for that analysis of the problems of generation which he

had been largely responsible for in the past. In this respect electrical generation would have to organise itself as a manufacturing concern on the broadest possible lines. Gas engineers were unable to take up the general question of the utilisation of fuel for the production of power, and the prospect of large gas-driven stations appeared to be receding more and more. The difficulties in the way of producing a satisfactory gas turbine were so enormous that unless some interest became strong enough to put down a sum of, say, a quarter of a million pounds for research on this question, it was very unlikely that anything at all would be done. In connection with such a sum he had been told that as much as this was spent in Bradford before the fabric "plush" was successfully made. If so much money could be found to utilise silk there was some hope that it would ultimately be found for a scheme which would bring much larger benefits to the community. Another question which Mr. Lackie had left over was that of how to deal with poor fuel. While he thought nothing could be done in connection with their gas engineering concerns, he thought there was much more possibility of a combination between the electrical generation interests and the coal winning interests. To make this effective we should have to arrange moderate size power stations at the colliery itself. One of the most striking developments going on at the time was the way in which the size of the colliery generating station was rising. Any scheme of linking up such as had been discussed at the Institution of Electrical Engineers lately would largely depend on the co-operation of colliery engineers, and they themselves were in several directions privately considering a considerable electrical linking up of allied coal interests. The possibilities in this direction appeared to have received very little attention. The difficulty of stations at the pit head was mainly one of water, and they must be prepared to sacrifice a very considerable degree of that efficiency which they had been accustomed to regard as essential in their big stations for the sake of getting poor fuel very cheap and having facilities for coal delivery and ash rejection, such as they would never get in the vicinity of their large towns. It was no handicap to have stations, say of 30 per cent. or 40 per cent. less efficiency than they had been accustomed to think of as imperative, if they could get fuel from half to one-third of the price per the B.Th.U. value in the fuel. Other difficulties lay largely in the method of payment for coal winning. As long as the collier was paid by weight of good coal, so long would he nurse his plausible but false economical conclusions as regards limitation of output.

A possible solution appeared to be that the power station should not buy the poor fuel at all—certainly not on weight—but should make an arrangement for partnership between the colliery company and the power company whereby a return for the fuel is based purely on units generated from it. Seams which were not now attacked because of want of profit in drawing, or from reasons such as a desire to keep the average quality on price of coal from the colliery at a constant high level, could under some such arrangement come into use. On the question as to whether the electrical undertaking could itself take over the production of coke and by-products, he could not see much light at present. It would mean a considerable change in design of boiler-houses and a large increase in staff, land required, and capital to be raised. The uses for coke were strictly limited and no stoker, so far designed, could operate satisfactorily from a mechanical point of view with this intensely hard fuel. He did not think that they need apprehend any serious difficulty in burning such fuel on a fixed grate, but some considerable advance would have to be made in stokers to operate with coke without any more wear and tear than they now had with good steam coal. They had, of course, to remember that only 50 per cent. of the coal produced was good coking coal, and quite a small proportion of this was burnt on chain grates. In fact, such coal was rather difficult to burn owing to its swelling up. A large proportion of coal would therefore still be burnt, but this did not affect the questions of drawing low-grade fuel from the mine instead of leaving it there. It was in this direction alone that he could see any promising outlook for the development of fuel economy on lines other than were being naturally brought about by purely economic reasons. This natural solution was that of extending their growing electrical supply undertakings, of which Glasgow was in the front rank.

Mr. T. Roles (Member of Council) (Chief Electrical Engineer, Bradford), referring to Mr. Lackie's remark that a 1 per cent. saving in coal consumption at Glasgow would mean a financial saving of £2,000 per year, said he thought there were very few boiler-houses in the country in which a 1 per cent. saving could not be effected, and this fact would justify the employment of skilled boiler-house engineers, as suggested by Mr. Fedden, in a considerable number of existing generating stations. This was a very good suggestion, especially in the case of large stations, and as regards Glasgow it was clear that the saving that could be effected would warrant the appointment of a number of such

engineers. He agreed with Mr. Fedden that the real question to be considered in the design of modern boiler-houses is that of load factor. The question of increasing the grate area somewhat on the lines Mr. Selvey had indicated should be looked into. In the Babcock marine boiler the grate practically covered the whole of the ground space, but with the land type of boiler the grate only took up a comparatively small portion of the space covered by the boiler, and had to project well in front of the boiler in order to provide sufficient surface. If the land type of boiler were elevated, as he believed was done in America, so that the grate area obtainable could be doubled, the evaporative capacity of boiler-houses per square foot of area could be greatly increased. One of the most important items in the paper had not been touched upon by previous speakers, and that was steam pressures. Steam pressure in present-day boiler-houses was about 180 to 200 lbs. per square inch. In Bradford a pressure of 200 lbs. was adopted some twenty years ago, but now it would seem that steam pressures must be increased. Turbine makers were talking of much higher pressures, one firm he believed now making experiments with a pressure of 350 lbs. per square inch. Engineers contemplating putting down new stations were at the present time, therefore, in somewhat of a predicament. Were they to put down boiler-houses with 200 lbs. pressure, or should they consider higher pressures, and if so, what was likely to be the standard ? If they decided on 350 lbs. it followed that the first individual or corporation who called for a 350 lb. pressure boiler, together with the necessary steam-pipes and valves, would have to pay practically all the development charges, and that deterred them from attempting pioneer work of this description. It appeared to him that the present was a very favourable time for the turbine makers and valve makers and boiler makers to come together, and discuss the question of what should be the standard steam pressure for the new larger boiler-houses that must be put down after the war, and he hoped that they, or the Engineering Standards Committee, or the British Electrical and Allied Manufacturers' Association would take this matter up, because it would mean the saving of a great deal of money, and it would also prevent the industry being placed in a similar position as regards steam pressures as that in which they had been placed in connection with voltages, periodicities, and other matters. The question of storing coal, he believed, had been taken up on a much larger scale on the Continent than in this country, probably because there they were not able to rely on regular deliveries at short

intervals. At Bradford, however, it had not paid to put in special apparatus to handle stored coal. It was just dumped in the works yard, and although it was a costly process to remove the coal from the yard into the bunkers by horses and carts, it was cheaper than sinking capital in plant which would probably only be used once in about seven years. Reference had been made to very high rates of evaporation per square foot of heating surface which the Americans obtained. It seemed to him a question of cutting down heating surface as compared with grate areas. He had found that, with the same grate area in each case, the steam raising capacity of boilers of from 7,000 to 8,000 square feet heating surface was very little different from that of similar boilers with two or three extra rows of tubes, making a total heating surface of 9,400 square feet. The rate of evaporation per square foot of heating surface in the case of the first-mentioned boilers would, however, be higher. He had also found that the prices of boilers of 9,400 square feet were but little higher than those of boilers of from 7,000 to 8,000 square feet, as it was simply a matter of paying for a few additional tubes, which was well worth doing in order to obtain the extra water capacity and the slightly higher efficiency. Finally, experience at Bradford had shown it to be, as a rule, the best policy to buy the best qualities of coal. Coal was bought on the basis of the cost per million B.Th.U., and a coal at 15s., 16s., or 17s. per ton was often very much better than one at 11s. or 12s. per ton on this basis.

Mr. H. J. S. McKay (Stirling Boiler Company) expressed himself as more in accord with Mr. Pearce's remarks concerning the two-story building than with Mr. Lackie. Mr. Pearce's conclusions that the cost of a two-story building in a large power plant saved something like 21 per cent. in capital expenditure coincided with figures that he himself had arrived at from time to time. With regard to Mr. Roles' remarks, as to difficulties with boilers constructed for 350 lbs. pressure, some years ago his firm manufactured some boilers for that pressure, and experience with these boilers permitted him to make the very definite statement that the only trouble encountered was with water gauges. This trouble had been completely overcome. Other anticipated difficulties did not arise in that particular plant at all.

With reference to Mr. Fedden's remarks regarding maintenance of stokers at Sheffield, Yorkshire coal is of a peculiarly

hot nature. Fortunately, most members of the Association are not required to burn coal of this quality. It is destructive to grate bars, especially when high calorific quality is used. The maintenance figures therefore given by Mr. Fedden per ton of coal burnt do not apply generally to chain grate stokers throughout the country.

Mr. J. H. Bowden (Member) (Chief Electrical Engineer, Poplar) said the opinions expressed in the paper practically confirmed the experience at Poplar where he had introduced the particular type of boiler mentioned in the paper some five or six years ago. He was sorry to admit that he inspected this type of boiler in a country whose name we did not care to mention at the present time, but he saw things there which led him to the conclusion that that boiler was the only one he could put in at Poplar in the limited space at his disposal. With regard to the evaporation per square foot of boiler space, it was interesting to note that, although the author mentioned an evaporation of 100 lbs., in actual experience he was getting nearer 113 lbs. on the boilers that he had referred to. In the paper, reference was evidently made to some particular type of stoker, and he had hoped that Mr. Lackie would say something with reference to a stoker which he himself was very much interested in when he visited the Glasgow power-house some year or two ago. It was an American stoker, and from what he saw of it, it seemed that it was possible to increase the output of the boiler very considerably by this means. Would Mr. Lackie say whether he thought that stoker could be made satisfactorily, and whether it would obviate the difficulty, trouble and expense that had to be faced with stand-by boilers for taking peak loads? He was also in accord with Mr. Lackie with regard to steam flow meters. Perhaps, however, he was more fortunate than others, because he had had some himself that worked very satisfactorily As to ashes, he would like to suggest for consideration whether the removal of ashes could not be done in some manner similar to that adopted at sea, namely, to deal with them by pumping in a similar manner to what they were doing with the coal, he believed, at Hammersmith. He had approached the people who made it, but they were not prepared to give him any quotation at that time although they went into the matter. He was very much in favour of the rotary type of boiler-feed pumps as against the old type for more than one reason. Firstly, it was not necessary for the pumps to be directly under the eye of the stoker, and they could be placed in the centre portion of the

basement which was only used for pumps and was quite accessible. Another advantage was that it did not require the stoker to be continually running backwards and forwards to the pump-house. He was able to start the pumps, and it did not matter whether the check valves were closed or not because the pump suffered no harm. Finally, the figures in the test at the end of the paper confirmed those obtained on tests of the boilers at Poplar.

Mr. J. P. Gregory (of the British Thomson-Houston Co.) expressed disappointment with the fact that although Mr. Lackie had referred in his paper to the adoption of steam pressures up to 250 lbs. in the States, apart from the comments made by Mr. Roles, the whole subject of using higher pressures and superheats had not been discussed. He spoke of the importance of giving this matter close study, both from the commercial and engineering standpoint, in view of the fact that with increased pressures and temperatures, and the utilisation of steam turbines, it is to-day possible to obtain very much higher overall thermal efficiencies than hitherto.

He also pointed out that high thermo-dynamic efficiency on a turbo-generator did not necessarily mean a correspondingly high overall thermal efficiency for the whole generating plant. To make his point clear he stated that his Company decided some considerable time ago to install as an experiment at their Rugby works a high pressure and high superheat plant. As the result of daily running over a considerable period, this plant had become a permanent part of the Company's power installation.

The equipment comprised a Marine type tubular boiler, with integral superheater, economiser, induced draught fan and chimney, 1,500 kw. Curtis turbo-generator, surface condenser, and turbine-driven boiler feed pump, the latter exhausting into the feed water tank. He incidentally mentioned that the hot air from the alternator was turned into the boiler furnace. The working pressure was 350 lbs. per square inch gauge, the plant being designed to give 700° to 750° F. total temperature to the steam. Tests had shown remarkably good results, which would doubtless be published in due course.

In order to make his point clear in regard to the increased overall thermal efficiency, Mr. Gregory gave the following figures :

He noticed Mr. Lackie referred to a thermal efficiency of 17 per cent. being obtained on one of the large plants in the States, and he presumed that this result was being obtained at pressures higher than those normally used in this country in the majority of the stations hitherto.

For comparative purposes, Mr. Gregory assumed a boiler efficiency of 80 per cent., which could be modified if necessary when making comparisons with any other boilers. It had been shown at Rugby that with 350 lbs. per square inch gauge pressure, 264° F. superheat, 28½-inch vacuum, the overall efficiency of the unit was 19·12 per cent. A similar unit at 200 lbs. per square inch gauge, 200° F. superheat, 28½-inch vacuum, would show 17·3 per cent.

The comparison would show still more in favour of the higher pressures and superheats adopted on this plant at Rugby, if the comparison was made with boiler pressures and temperatures still lower and more in line with those used up to the present in this country.

Mr. Gregory also showed that by reducing the pressure from 350 lbs. per square inch gauge to 200 lbs., but retaining the same degree of superheat, *i.e.*, 264° F., the overall thermal efficiency would come out at 18·5 per cent. In other words, whereas the decrease in thermal efficiency by retaining the high superheat was 3 per cent. by decreasing both pressure and superheat the loss in efficiency was nearly 10 per cent. as compared with the results at the pressure and superheat used on the Rugby plant.

The result of operating the plant referred to by Mr. Gregory —which is self-contained in its own power-house—as compared with their normal works plant, has shown a saving of 1 lb. of coal per unit generated. This result is being obtained in spite of the fact that the Company's ordinary power-house plant consists of modern engines and turbine plant operating at the usual pressures and temperatures prevalent in the average municipal station.

Mr. G. Wilkinson (Past President) (Borough Electrical Engineer, Harrogate) hoped that one outcome of the discussion would be a deep feeling of dissatisfaction with our boiler-houses

as we know them to-day. The author of the paper said that in the earlier days 1 h.p. per square foot of engine-room floor space was the usual figure, whereas to-day it was 5 h.p., and he forecasted a time when we should have 20 h.p. per square foot. Then, in the next paragraph, the paper stated that changes in boiler-house design to secure the increased demand for steam were absolutely imperative, and he cordially agreed. The point was how could we improve our boiler-house evaporation ? In his opinion there were two ways, one by increasing the heating surface, and this could only be done at the tail end of the boiler, *i.e.*, the portion of the heating surface remote from the furnace, whilst the other way was by increasing the rate of evaporation per square foot of heating surface. With the present method of using our fuel, it was only possible to have a heating surface in one horizontal plane which represented the aggregate area of the furnace. There were practical difficulties which prevented us from working the whole of the boiler-house area as one huge furnace and the limitation was very definite. Mr. Lackie expressed the opinion that the ultimate development of the coal furnace would be a combustion of 100 lbs. of fuel per square foot of area. He was pleased to hear Mr. Lackie was so sanguine. He personally had made careful study of boiler-house practice, and had failed to find any boiler-house which, in regular daily work, did more than 30 lbs. to 35 lbs. of fuel per square foot of grate area. That being so, it was worth keeping in view the fact that boilers had immense capacity for taking up heat if the heat could only be got to the heating surface. With a good water and clean surface, 70 lbs. of evaporation per square foot of heating surface had been obtained, and there was no doubt that in regular working a rate of evaporation of 35 lbs. could be obtained, but it could not be done with our present methods. Mr. Pearce had shown plans of his new boiler-house, and he was surprised that he had only allowed for $4\frac{3}{4}$ lbs. of evaporation per square foot of heating surface. This seemed a very low figure, because Mr. Lackie spoke of 8 lbs. and ultimately 10 lbs. He thought the way to make progress in this matter was to deal with the heating in quite a different way. Mr. Christie had already foreshadowed a method, and that was by having a more flexible application of the heating element. He hoped the scheme at Brighton for using gas would be realised, because that allowed a heating medium in such a flexible condition that radiant heat could be plastered over the whole of the heating surface. Mr. Christie's difficulty would be that for the equivalent of every ton of fuel burnt in the ordinary

boilers, by his method he would have about 12 tons of coke in the way of by-products to dispose of. If the Associated Company which was co-operating with Mr. Christie could sell that, well and good, but as central station engineers they could not entertain anything of that description because electricity works would then become coke-producing works and the electricity would simply be a by-product and not the principal item. On the other hand he would suggest that Mr. Christie should take the extra 60 per cent. of fixed carbon which was in the coke in the form of gas, thus obtaining the maximum amount of gas and reducing the fuel right down to ash in the gas producers. In that way a very fine efficiency would be obtained. Having considered this matter with some care he had arrived at a number of advantages to be obtained from this method of firing boilers, amongst which may be mentioned the following :—

(1) Cheaper and simpler type of boiler.
(2) Accelerated combustion with cleanliness and no smoke.
(3) Smaller and cheaper boiler houses.
(4) Better control and quicker response.
(5) Increased boiler efficiency.
(6) Smaller steam pipe losses.

He had hoped that Mr. Lackie would have said something in his paper about what was being done in Glasgow with the gas firing installation. The steam per square foot of heating surface would be about quadrupled in large plants, and the valuable by-products should produce a revenue equal to approximately 30 per cent. of the original cost of the coal in large plants.

Bailie W. B. Smith (Member of Council) (Glasgow), said he had only been drawn into this discussion because of what had been said as to the gas-firing of boilers. Mr. Wordingham had said that this subject would have to be attacked by joint action between gas engineers and electrical engineers, but the Corporation of Glasgow had anticipated that. Over two years ago a joint sub-committee consisting of members of the Gas and Electricity Committees agreed upon a joint experiment with regard to gas firing of boilers. That had been going on at one of the electricity works, one of the experiments being to convert the coal into gas and use it as a heating medium, getting at the same time those valuable by-products which up till now electrical engineers had sent up their chimneys into the atmosphere. It was too soon to give any results, but he hoped that by next

year a paper would be read on the subject. Meanwhile, they were trying experimentally a new process. If it proved to be a good one they would adopt it, but if it did not prove to be a good one they would look for some other process. Most encouraging and surprising results were being obtained in low temperature carbonisation and by-products were being obtained of a much higher value than had been anticipated. Incidentally, they got the coke in such a form that it would burn in an open grate, and it gave every appearance of being an ideal smokeless fuel. If, however, they did not want to sell the coke, there was nothing to prevent it being burned in the boilers. Mr. Lackie had recently made an experiment with ordinary gas-coke in his boilers and got good results. Hitherto, the difficulty had been that the cost of gasifying the coal had been more expensive than the return from the by-products, but there was every sign that the process being tried now would enable the coal to be gasified at a very low price, so that the revenue from the by-products would exceed the costs of the capital expenditure upon the gasification plan.

On the motion of the President a hearty vote of thanks was accorded to Mr. Lackie for his paper.

Mr. Alex Dow (Detroit), (*communicated*), says : This is written in response to the request of the Secretary of the I.M.E.A. for information as to the actual working of the Detroit Edison boilers with 23,654 square feet of evaporating surface per boiler. These were brought to the attention of engineers at large by the paper of Dr. D. S. Jacobus presented at the Annual Meeting, December, 1911, of the American Society of Mechanical Engineers. That paper was a brief description of the boilers, and a full report of a series of efficiency tests made under the direction of Dr. Jacobus.

Mr. Lackie's information as to the number of these boilers in service is not quite correct. They have thirteen of them—nine at Delray and four at the new Connors Creek plant. Two more, making fifteen, will be installed at Connors Creek this summer. The Solvay Process Company uses similar boilers at its Syracuse plant, but the very large boiler has not yet found general acceptance. The smaller boiler of the same type, having 10,000 to 12,000 square feet of evaporating surface has a considerable

vogue. The excellent shape of the combustion chamber is common to both the large and the small boiler. And, of course, extremely large boiler units are not suitable for every plant.

The suggestion that such boilers might be built was presented to the Babcock & Wilcox Company (U.S.A.), in the summer of 1906, and after discussion and study, the B. & W. Co. in 1907 expressed its willingness to accept an order. Intervening circumstances, including the panic of 1907, delayed the giving of the order until 1908. The first boiler was installed in 1909 and two others in 1910. The Jacobus tests were made in the summer of 1911, after we had assured ourselves, first, that the boilers were highly efficient, and, second, that they would, without stress, make more steam than we had expected. The intent of the tests was to determine, (1) the best method of operating, and (2) efficiency under varying loads.

After the Jacobus tests they set themselves to do two things ; (1) to attain in every day service, as nearly as might be, the results obtained in the tests made under skilled direction ; and (2) to ascertain the maximum economical output of the boilers—fuel, labour, maintenance, and investment being all taken into the calculation. Mr. Dow has asked Mr. James Wentworth Parker, Junior Member of the A.S.M.E., who lived with the boilers during the Jacobus tests and for several years afterwards, and is still responsible for their efficient operation, to write a short statement of the operating results obtained. He now states briefly the difficulties met and the results obtained in their search for the upper limit of output.

The first check to their progress towards increased output was had before the Jacobus tests. It was that the baffles between the first and second passes, which were supported in the customary way by iron framing, would not stand the temperature. The remedy was to change the bending of the last row of water tubes in the first bank and make these tubes carry the baffle tiles.

Check number two was, in effect, that no refractory materials on the American market would stand the punishment to which the ignition arches of overfeed or chain grate stokers, and the low partition wall between the two halves of the first design of

furnace, were subject when the boilers were driven. The underfeed stokers of the Taylor type required no brick in such positions, and after they had been modified to our specifications, we adopted them as standard.

The side walls of the furnace gave them check number three. These high walls were built by us in seven different ways before we standardised them. None of the ways tried were bad. All the materials tried were good. But we finally learned that a somewhat soft and porous fire brick, nearly neutral—that is to say, neither basic nor acid—was necessary ; and that the brick must be laid to give a surface slightly concave—say saucer shaped—on the side next the fire. Mr. Dow points out that the selection of fire brick in such a case requires the same study as the selection of the lining of an open hearth steel furnace. There are bricks, *and* bricks. Likewise there are fuels, *and* fuels. And the combination of brick *A* with fuel *B* may be very bad indeed.

At this stage of the proceedings they ran into stoker difficulties. Assemblies of tuyeres, proven out in ordinary practice, puckered up most aggravatingly under their efforts to reach maximum boiler output. Likewise there were experiences with fans. But each of these is another story. They now have fans which are compact, efficient and reliable, and their stoker maintenance is a petty item in power-house costs.

Check number four was met at Delray and is still the limit there. It is that the damper opening and the curved connection to the uptakes limit the discharge of flue gases, and thereby the amount of coal which can be burned. By the time they had recognised this limit, they had learned that two boilers would serve a 14,000 or 15,000 kw. vertical Curtis turbine unit, with its auxiliaries ; and as one boiler obviously would not do the work, we could not cut down required investment by moving steel columns, etc., to make room for larger flues. But in planning the Connors Creek installation we took more room, and thus avoided that limitation.

About this time Professor C. F. Hirshfield of Cornell University (Member A.S.M.E.), who had joined them as Chief of their Research Department, made precise determinations of the distribution and values of the pressures required to move products

of combustion through all the gas passages. That, likewise, is another story. His work led them to make certain modifications in the baffling of the Connors Creek boilers, and gave us the data for selection of fans and for determination of chimney height.

Please observe that, thus far, the limitations found were all external to the boiler proper. Check number five was the quality of feed water. It became evident very early in the game that they could not afford to use, for make-up, any water carrying scale-making solids. The amount of make-up required at Delray had never been excessive, but we reduced it very much by limiting the blow-off to the amount proven to be necessary, and by returning every possible drop of drips. To distil, or to treat chemically, make-up equal to 1½ per cent. of the total evaporation, is not difficult, and is essential if maximum capacity is to be obtained. At Delray they treat the make-up. At Connors Creek they distil it.

Check number six they are now studying. It is internal to the boiler. The gas temperatures in these furnaces are 2,800 Fahr. and upwards, therefore the tubes next to the flame receive daily a very severe heat treatment. In these latter years American practice has been to use a seamless boiler tube of low carbon steel. Such a tube stands a great deal of mechanical punishment and is not changed in texture by ordinary furnace practice. But under the Delray and Connors Creek conditions there is in time a change in the tube material, which is shown in micro-photographs as an increase in the size of crystals. Their studies indicate that boiler tubes, to be driven as are ours, should be made of a steel having considerably more carbon. They are not yet ready to specify an analysis. It may be that a so-called alloy steel will be commercially preferable to a high carbon steel.

The upper limit which has been attained is as follows :—

In regular practice they work the Connors Creek boilers up to an hourly output of 130,000 lbs. of steam per boiler and down to 48,000 lbs. per hour before banking ; the pressure at the superheater outlet being 225 lbs. and superheat 180 degrees. By firing only one half of the furnace and by other obvious devices, they can operate the boilers at still lower ratings with good efficiency, but in practice this is neither necessary nor desirable. In brief, each boiler, whether at Delray or Connors Creek, is

operated at any output required by the conditions from 48,000 lbs. of steam per hour to 130,000 lbs. of steam per hour. And neither boiler, stoker nor furnace is strained at the upper limit. The fuel is a West Virginia, long-flaming, bituminous coal ; sulphur content less than 1 per cent. and heat units (taken one year with another) about 13,650 B.Th.U. per pound as fired.

These are the limits in everyday practice. Now as to what can be done in case of emergency. The Connors Creek boilers, because of their better flue arrangements, and higher furnaces, are, of course, those which will give the highest output. In testing out a modified fan design, the fan being duplex and the problem being whether the two sides of the fan would divide the work evenly under all conditions of fuel bed, they drove one of these boilers for an hour with output at rates between 185,000 and 192,000 lbs. They have steam flow meter readings for this, but the best evidence is that the boiler was feeding a horizontal Curtis turbine, 25,000 kw., and its auxiliaries, which turbine during the test was held as nearly as might be at an output of 16,000 kw. Another record came accidentally on a Saturday afternoon last year when, by prearrangement, Connors Creek station was to carry only 8,000 to 9,000 kw., and one of the two boilers then in commission was banked preparatory to being cleaned, leaving one boiler connected to the steam main. New cable connections were being made. An accident to one 23,000 volt cable, and a blunder by a construction foreman, who was " cutting in " a new substation, isolated the east and (the Connors Creek end) of the network with a load, thus isolated, of 17,000 kw. The frequency went down from 60 to 58, and there was a dip in the voltage for a minute as shown by the recording instruments ; but the one boiler pulled the load for the twenty minutes, until the other boiler, which had been banked and disconnected, was brought in again. Under the most favourable arrangement of auxiliaries this would require steam at the rate of 204,000 lbs. per hour. There was a clean thick fire under the boiler when the trouble began. All that was done by the fireman was to open the motor operated dampers between the boiler and the chimney, speed the motor-driven blower to give the blast, and increase to a relatively *less* extent the feed of coal to the stokers. Of course the fires were burned thin when the second boiler came into commission, but that was the proper way to deal with such a sudden demand for steam.

Mr. Lackie's commendation of larger boilers, a bright and

clean boiler-room, and a superior class of fireman, is heartily approved by Mr. Dow, and by his associates and staff. They have been fortunate in Detroit in the opportunity to show forth their faith in these matters, not only with their lips but in their practice ; and they wish like good fortune to Mr. Lackie.

Mr. James Wentworth Parker (Junior A.S.M.E.) (Detroit) (*communicated*) says : A brief description of the boiler-rooms of the Delray and Connors Creek power plants at Detroit will help to make clear some of the statements in subsequent paragraphs.

The Delray plant consists of two power houses interconnected electrically and by water and steam lines. In the newer house there are installed and running nine Stirling boilers of the " W " type, each of 23,654 square feet of effective heating surface exclusive of superheater surface. In this section of the plant there are no economisers. There are four stacks of steel plate, riveted and caulked, and brick-lined. They are erected upon the top of the steel structure of the boiler house ; three serving two boilers each, and one serving three boilers. The older section of the plant contains twenty-four Stirling boilers of the well-known older type, each of 4,834 square feet of heating surface exclusive of superheaters. Cast iron economisers of the Green type are so arranged that one economiser serves two boilers. There are two steel plate brick-lined stacks on independent foundations—each serving twelve boilers.

Coal is brought into this plant in standard gauge railway cars and dumped through hatches in the car bottoms into hoppers underneath the tracks. From the track hoppers, the coal runs by gravity into two-ton skips, and is hoisted to the top of a tower where it is crushed, and thence distributed by a cable railway to bunkers above the boilers.

All of the boilers are served by Taylor underfeed stokers, except one large boiler, which has a Westinghouse underfeed stoker.

The Connors Creek plant has been but recently built and the boiler-house represents our later ideas of boiler-house design. Here are installed four of the 23,654 square foot type " W "

Stirling boilers, with Taylor underfeed stokers, and without economisers. Two more boilers are on order for delivery this summer. As at Delray House No. 2, the stacks are set upon the building structural steel above the boilers, one stack serving two boilers. Coal is dumped from the railroad cars into track hoppers, lifted to a crusher at ground level and then elevated to the bunkers on the top of the house by bucket conveyors. The whole arrangement of coal handling and ash disposal is simpler than at Delray. Five men unload, elevate and distribute all of the coal and dispose of all of the ash. The ash is discharged continuously and automatically by the stokers into pits directly underneath the furnaces and from these is drawn through bottom gates into standard gauge steel railway cars standing immediately below the ash pits. The movement of railway cars under the stoker ash pits is made possible by a rather high elevation of the boiler-room floor. There are no siftings or riddlings to be disposed of with our type of stoker.

For comparison with Mr. Lackie's figures he offers the following :

In the Connors Creek boiler-house, the normal evaporation from and at 212° F., is 32 pounds water per hour per square foot of boiler-house. In this statement of boiler-house area is included the coal unloading house, in which are two parallel railroad tracks. The evaporation per square foot of boiler-room proper, is 43 pounds.

The evaporation per square foot of boiler floor space is, normally, 155 pounds per hour per square foot. The area occupied by boilers is 28 per cent. of the boiler-room proper. The entire floor space between the two mud drums is available for furnace area, the grate area, projected upon the horizontal plane, being 427 square feet per boiler, which is 42 per cent. of the boiler floor space.

In the light of the experience had at Delray in burning the long-flaming bituminous West Virginia coals, it was decided to raise the boilers at Connors Creek three feet higher above the grates than at Delray, giving a combustion chamber volume of 18 cubic feet per square foot of grate area.

Something should be said as to boiler-room instruments. It

has become the Detroit Edison Company's practice to install for each boiler a gauge board, set upon the boiler-room floor and directly in front of the boiler unit, to which board is brought almost the entire control of the fire. On it are mounted the controllers for the motors driving the stoker fans, and for the stoker motors, these motors being arranged for variable speed; also the control of a small reversible motor for setting the boiler exit hampers. Above these controllers are mounted the instruments, consisting of a steam flow meter to show the output of the unit, a CO_2 recorder showing an average analysis of flue gas samples drawn from four points of the setting; and, lastly, three draught gauges. One of these shows the air pressure under the grates. Another, graduated in hundredths of an inch, shows the draught at the exit dampers, and the third, similarly graduated, the draught at the top of the combustion chamber. An effort is made to keep the draught at this latter point as nearly as possible the same (between 0 and ·10 inches of draught) at all rates of evaporation. A greater draught tends to cause unnecessary infiltration of air, whereas less would permit serious fluxing of the furnace brickwork.

Manual labour by the firemen is eliminated as much as possible and they are coached to give their entire attention to the combustion of the fuel. The operating force is organised with this in view. A boiler-room foreman on each eight-hour watch has general charge of the handling of the boilers and their auxiliary apparatus, attending to the many things which distract a fireman from the work of firing proper. A combustion engineer for each watch, usually a University graduate in engineering, has direct charge of the firemen. One fireman works two large boilers.

In the following table are given the average boiler-room costs and also the total production costs per nett kilowatt-hour for the Delray and Connors Creek plants during the twelve-month period ending April 30th, 1916. It is necessary to pro-rate between boiler-room and turbine-room operation certain general expense items, as noted, but this has been done for each item as carefully as possible.

BOILER-ROOM EXPENSE.

(In fractions of a cent per kilowatt-hour of net output.)

Twelve Months Ending April 30th, 1916.

Accounts and Sub-Accounts.	Delray.			Connors Creek.	
Boiler-room Labour		·028			·0294
Coal handling	·0053			·0051	
Firing	·0136			·0127	
Care of boilers, heaters and economisers	·0019			·0012	
Ash handling	·0028			·0014	
Care of electrical apparatus in boiler-room	·0006		pro-rated	·0024	
Routine testing	·0011		,,	·0006	
Care of buildings	·0015		,,	·0031	
Miscellaneous labour	·0012		,,	·0029	
Miscellaneous supplies		·0043	,,		·0044
Fuel		·1995			·1599
Maintenance of boiler-room		·0230			·0176
Building	·0028		pro-rated	·0036	
Boilers	·0017			·0025	
Settings	·0051			·0022	
Feed pumps	·0002			·0006	
Draft equipment	·0005			·0015	
Stokers	·0059			·0020	
Coal-handling equipment	·0017			·0014	
Ash-handling equipment	·0006			·0001	
Heater system and economisers	·0005			·0018	
Steam and water piping	·0007		pro-rated	·0009	
Permanent instruments	·0004		,,	·0003	
Machine tools	·0004		,,	·0002	
Stores Department expense	·0025		,,	·0005	
Total boiler-room expense		·255			·211
Total production expense (Includes boiler-room expense, as above, and all other power-house expenses.)		·294			·270
Total output for the period, net kilowatt-hours	332,750,800			110,202,900	
Maximum load during the period, half-hour reading, kilowatts	86,200			20,000	

The total production expense given in the foregoing table represents the entire expense of operating and maintaining the plants. In maintenance expense, it is the Company's custom to include not only repairs of all equipment but, in addition,

minor replacements or betterments. These figures are calculated on the basis of net output metered to feeders, all electricity used within the plants being deducted.

The average overall boiler efficiency of the Delray boiler plant (that is, ratio of heat in steam delivered to turbine-room by boilers, to calorific value of coal as fired) is 76 per cent. It should be understood that this figure is based on the metering of boiler feed water by Venturi meters and is checked by the known water rates of the turbines. It is reasonable to expect, therefore, that it is correct to within 2 per cent.

For Connors Creek plant the same overall boiler efficiency *i.e.*, 76 per cent., is arrived at by a similar calculation.

It should be noted that the Delray plant has economisers on the small boilers in the older house (*see* the preceding descriptive matter), but none of the large boilers at Connors Creek or Delray has any economiser. The stated Delray efficiency includes this partial economiser effect. The stated Connors Creek efficiency is for boilers alone.

The ratio of British thermal units in the coal to net kilowatt-hours delivered to feeders by the plants, for the twelve months ending April 30th, 1916, is 23,750 B.Th.U. per kilowatt-hour for Delray, and 20,101 B.Th.U. per kilowatt-hour for Connors Creek.

The figures for coal represent all coal burned, no deductions having been made for the heating by steam of the plant proper, warehouses and certain outlying shops, which require considerable heat.

Mr. Lackie's observations on instruments for combustion control are most interesting, and not least valuable is his advice concerning the use of a dial thermometer showing the temperature of superheated steam leaving the boilers. Taken in conjunction with readings of the steam flow meter, the steam temperature is a very sensitive indicator of combustion conditions, both as to excess air and as to secondary combustion.

With our high combustion chambers we have been able to maintain very good CO_2 and yet avoid loss due to the escape of unburned volatile gases from the combustion chamber. About 14 per cent. of CO_2 is a fair average over long periods, while

16 per cent. is not at all uncommon. With Stirling type "W" boilers, a valuable indication of secondary combustion may be had by observation of the gases as they tumble over the first baffle to enter the superheater pass. Here the very characteristic CO flame gives instant warning of such loss.

If it were necessary to limit ourselves to a minimum number of instruments, we would install first two draft gauges, one indicating the blast pressure, if the boilers were equipped with underfeed stokers, and the other indicating the draught at the top of the combustion chamber as described in another part of this discussion. The choice of the proper draught setting at this point would vary with different types of settings but would be the same for all identical settings and constant for various ratings.

The next instrument to be chosen in the order of the significance of its readings would be a CO_2 indicator or recorder, supplemented by a close watch for secondary combustion.

Mr. Horace Boot (*communicated*) says: The author states "No very great increase in boiler efficiency is possible," which means that they must look further afield for future economy. This, Mr. Boot thinks, will come in extracting the valuable by-products in bituminous coal before utilising it for steam-raising purposes.

Consider what one ton of bituminous fuel contains. If properly split up, there would be about 15 cwt. of smokeless fuel; $3\frac{1}{2}$ gallons of spirit; 4 gallons of refined oil; 4 gallons of crude oil; 24 lbs. of ammonia; there will then be the tar and pitch; and 5,000 cubic feet of gas.

Assuming pre-war prices, the value of bituminous coal then costing an average of 18s. per ton, when treated for these by-products becomes worth 31s. per ton. This is making no allowance for the value of the heat in the gas. It must be borne in mind however that such a chemical reduction works can only be carried out on a large scale and it would be absurd for small electricity works to suggest using their coal in this way; but Mr. Boot thinks that in the case of the large consumers of coal in this country, it would be well worth their while to put down a by-products plant and extract the by-products before finally utilising the fuel; or what would be a valuable suggestion is for several large electricity power stations to combine to buy

up certain coalfields, put down their own works for producing these by-products and utilise the residual fuel and gases for generating electricity.

Mr. Boot is of the opinion that all coal containing more than 30 per cent. of volatile matter should be treated in this manner ; for it certainly cannot be burned without excessive smoke.

How many of our furnaces comply with the necessary laws of good combustion ? such as :

(1) Maintaining a high ignition temperature.
(2) The correct amount of air.
(3) The perfect mixture of hydro-carbon gases.
(4) The slow chilling of the products of combustion.

In several power works Mr. Boot recommended the use of coke breeze and gas oven coke mixed with a low grade duff fuel. To enable this to be burned successfully a special form of mechanical stokers have to be used ; and it is preferable to feed the duff and the coke separately, and at different rates, so that they mix together in coming into the furnace at a predetermined rate.

When one considers the percentages of coal as mined, and prepared for the market, always assuming as is the case, that in large collieries a breaking, classifying, and washing machinery are installed, the result of passing it (through this machinery) being as follows :—

About 45 per cent, of the Welsh coal is large and will sell at (in normal times)	- - -	About	23s. per ton.
About 10 per cent. of cobbles would sell at	-	,,	24s. ,,
About 10 per cent. of nuts would sell at	- -	,,	25s. ,,
About 10 per cent. of beans would sell at	- -	,,	18s. ,,
About 5 per cent. of peas would sell at	- -	,,	15s. ,,
About 20 per cent. of the coal is culm and duff and would sell at	- - - - -	,,	5s. ,,

The above prices are more or less relative, depending upon the markets.

There is no doubt that Mr. Lackie has struck the right note when he deals with " the importance of the work of the scientific boiler-house engineer and the necessity for cultivating and thoroughly educating this man."

Mr. Lackie speaks about the removal of ashes by suction plant. At one power works Mr. Boot has tried this most successfully and has designed a scheme for carrying it into effect. He does not

see any reason why suction plant would not be successful in handling very small coal and duff, the same as it handles most successfully cement, in cement works.

Mr. H. Martin (Victoria Falls and Transvaal Power Company) (*communicated*), says he has read Mr. Lackie's paper with particular interest, on account of the work he was doing in South Africa until August last, as boiler-testing assistant to the chief of the Research Department of the Victoria Falls and Transvaal Power Company.

He feels that with the object of effecting further economies in fuel in future, it is the operation of the boiler house which offers more scope for investigation and attention, and he should have liked Mr. Lackie to have given his views in this direction in more detail.

With a well-known type of boiler, reasonably well-maintained burning a familiar kind of fair quality fuel, and operating on a steady load, there is no difficulty in obtaining high thermal efficiency.

There are, however, generally many avoidable losses brought about by incorrect handling of boiler plant, when meeting the demands of varying load, and the requirements of cleaning and general maintenance.

Many of these losses would undoubtedly be demonstrated very clearly, by an efficient type of steam meter, one of which, as Mr. Lackie recommends, should be connected for each boiler.

He would be glad to know the type of meter the author would suggest, and what his opinion is, of its reliability, accuracy, and sensitiveness ?

As the result of boiler tests which Mr. Martin has conducted on various boilers, using an improved type of mercury manometer, in conjunction with Pilot tubes or orifice plates in the boiler delivery pipes, and arranged to indicate reverse flow of the steam, he has been surprised at the sensitiveness of a water tube boiler, to even the slight variations in heating, incidental to their normal operations.

A meter of this type will demonstrate clearly the effect of covering up a rather bare back on a chain grate, and also the set-back produced by careless or languid operation of the tipping plates when cleaning fires.

He has been surprised to find how quickly such a boiler is affected by reduction of draught, and how easily it will become actually a condenser on a superheated steam range, if not fitted with non-return valves (which he does not recommend) and carelessly operated.

He hopes that some discussion may take place, regarding the economical limit of increase in the steam pressures in modern boiler-houses.

Mr. C. Erith (Erith's Engineering Co., Ltd.) (*communicated*), states that on his recent visits to large American power stations, he noticed great differences of practice as to boiler heating surface installed per kilowatt turbine capacity, and also as to whether or not it was desirable to use economisers and induced draught, and to cut down the boiler heating surface.

A most remarkable instance of the latter practice is now being carried out by the Buffalo General Electric Co., who are installing five boilers each for 10,000 kw., the boilers being the 3-pass Babcock with superheater and overhead economiser, but with only 11,400 square feet—1·14 square feet boiler heating surface per kw.

Each boiler, including the stokers, occupies only 30 × 30 feet floor spare—900 square feet, and has an undivided furnace 26 × 16—416 square feet, fitted at each end with the latest type of multiple-retort grateless stoker. Combustion is evenly distributed over all thirty retorts, so that at the easy duty of 5 cwts. coal per retort hourly, $7\frac{1}{2}$ tons coal can be smokelessly and efficiently burnt without forcing. With this grateless underfeed combustion, there are no appreciable riddlings, and no arches whatever are used. All the tuyeres on all the thirty retorts are reciprocated, continuously slicing every part of the fire, and continuously discharging the ash at the centre of the undivided furnace, which needs no bridge walls.

It is, however, much more usual to install the same make of stoker, having fourteen, fifteen, or sixteen retorts, in a single-ended furnace on any standard boiler, with either horizontal or vertical tubes, and having from 10,000 to 12,500 square feet heating surface, for half the duty, viz., 5,000 kw.—viz., 2 to $2\frac{1}{2}$ square feet boiler heating surface per kw.; and as this method of combustion avoids all perishable arches or other special brickwork, and easily maintains 12 to 14 per cent. CO_2

at varying loads, the boiler efficiency is so high that an economiser could only add about 5 per cent. to the efficiency, and therefore in most cases the gases discharge direct to an overhead chimney, the usual practice being a 165 × 12 feet steel chimney for each range of five such boilers. Each such boiler, together with its stoker, only takes about 900 square feet floor area for 5,000 kw.

Multiple-retort underfeed stokers have enormously increased the capacity and efficiency of all types of boilers; and in the latest type, where the travel of the tuyeres is adjustable to suit different kinds of fuels, and the ash continuously discharged, and the same unit construction used whether there are 3 or 30 units or retorts fitted to a boiler, and no arches required, the greatest range of fuels is assured.

With the British-made stokers of identical design, the same diversity of practice has arisen in England; for instance, at Hull Corporation and at West Hartlepool Corporation, the new large-unit boilers discharge gases direct to chimney, as the small saving which an economiser with its induced draught fan could make is not considered to justify the expense and complication. The test in Appendix 4 to the present paper, shows that with over 12 per cent. CO_2 on both the 5-hour normal and the 1½-hour overload test, the economiser received so little waste heat that the feed temperature was only raised 90° F.; so it is certain that with an archless furnace and completely underfeed combustion, making it easy to maintain 12 to 14 per cent. CO_2 in every-day working, an economiser and induced draught plant is very costly for the small work it can do.

With dear fuel and a good load factor, however, the extra 5 per cent. efficiency will warrant these accessories; and the new Westbank station of the Edinburgh Corporation is a case where their cost is justified. There, two large Stirling boilers, each 8,500 square feet heating surface, are provided per 5,000 kw. generator; 3·4 square feet boiler heating surface per kw. installed. Each boiler has a 10-retort continuous-cleaning grateless stoker, easily capable of burning 2½ tons of fuel hourly.

Although high boiler efficiency is thus secured, an economiser and induced draught fan is placed behind the pair of boilers; and further, the fan which furnishes air for combustion to the two 10-retort stokers handles the warm air that has cooled the 5,000 kw. generator.

The Connors Creek plant at Detroit, referred to by the author, is a remarkable example of a large boiler-house; when completed, it will be 120,000 kw. capacity, and the boiler-house will be actually smaller than the turbine-room with its switch-house; the boiler-house being 270 feet long by 135 feet wide—36,450 square feet area, to hold twenty double-ended boilers, each 34 × 30 feet, or 20,400 square feet.

Another recent plant in a city area is 60,000 kw. capacity, having boiler-house 147 × 173 feet, viz., 25,431 square feet floor space, and holding 4 rows each 5—20 boilers each 10,000—200,000 square feet, viz., 3·3 square feet boiler heating surface per kw. installed.

This corresponds closely to Fig. 3 in the paper, viz., for same 60,000 kw. capacity two separate boiler-houses each 149 × 80 feet, total 23,520 square feet floor area; and holding 16 boilers of similar size and presumably with rather more heating surface, each shown with three long chain-grate stokers, overhead economiser, and 8 induced draught fans.

As it is perfectly easy to support a good steel chimney on girders, and to discharge the products of combustion at least 200 feet above the firing level, there seems little reason for the low-level chimneys indicated in the paper. At Chicago Edison plant, where the fuel is particularly suited for chain-grate stokers, there are only four boilers installed for each 20,000 kw. turbine; each boiler has chain-grates of 275 square feet area, superheater, overhead economiser and induced draught fan; but 8 such units discharge into a chimney 250 feet high.

These induced draught fans give 3·2 inch suction at economiser gas exit, and 1½ inch suction at boiler damper, as the duty of 5,000 kw. or 65,000 lbs. steam per boiler involves extremely high rates of combustion of the low-grade fuel, which has to be watered. The test figure was 18,300 B.Th.U. per kilowatt hour—18·65 per cent. efficiency; and it seems very probable that the report of an average of 1·92 lbs. coal of 10,120 B.Th.U., viz., 19,450 B.Th.U. or 17 per cent. efficiency, relates merely to a test run, and not to a whole year's run as stated by the author.

On the other hand, the report of 20,000 B.Th.U. in coal or say 17 per cent. thermal efficiency at the new Connors Creek

plant at Detroit is quite credible, as this plant has the most modern 20,000 kw. turbo-generators, an excellent load factor, a very excellent coal, and a highly efficient firing system worked at easy duty.

Each 20,000 kw. set is supplied by two huge boilers, each boiler having an undivided double-ended furnace, with combustion equally distributed over 26 grateless underfeed stoker retorts; there are no arches, no banking losses, no appreciable riddlings and very low heat losses in radiation and in ash; 12 to 14 per cent. CO_2 is maintained at all loads, so that 1·42 lbs. excellent coal, say 20,000 B.Th.U. or 17 per cent. efficiency, is commercially practicable. At full load, 20,000 kw. at 1·42 is 28,400 lbs. coal hourly for both boilers, or less than 5 cwts. of excellent coal per retort hourly, which is very easy duty.

This Detroit result is strikingly confirmed by results at Interborough, Seventy-fourth Street plant, New York, where the monthly average efficiency of the new 30,000 kw. sets is also about 1½ lbs. excellent coal, say 20,000 B.Th.U. in coal or 17 per cent. thermal efficiency; *see* Mr. Stott's paper read May this year to the American Society of Mechanical Engineers. The firing method is just the same as at Detroit, viz., grateless underfeed stokers with no arches, no riddlings, no banking losses, very high CO_2 and very excellent coal; but the stokers are of smaller size, 7 retorts each, and applied to old boilers each 5,200 square feet and superheater; four such boilers with 28 retorts do similar duty to one boiler at Detroit, 23,654 square feet, with 26-retorts stokers; in each case the stokers work at very easy duty.

Mr. Stott's paper shows that on 3-hour tests, the thermal efficiency was practically 25 per cent., equal to the best gas-engine efficiency; while the monthly average is 17 per cent.

At Port Dundas, as will be seen from Appendix II. that with 46·47 per cent. load factor, the weekly average is 3·2 lbs. coal of 11,500 B.Th.U., viz., 36,800 B.Th.U. or under 10 per cent. thermal efficiency, with chain-grate stokers and modern turbine plant; showing a very striking difference from the test efficiencies recorded in Appendices III. and IV. for the same overfeed firing method. On expert tests, splendid figures are attained with all firing methods; but in normal working, the grateless, archless, multiple-retort underfeed stoker has great advantages over earlier types of stokers.

Mr. Yorath Lewis (British Niclausse Boiler Company) (*communicated*), points out what the Niclausse equipment offers towards overcoming the boiler house difficulties, especially those to which so much prominence is given in the paper, and chiefly space occupied.

Fig. 1 illustrates the boilers at Southend : Type " B " brickset in battery of two, capacity each 22,500 to 30,000 lbs. per hour actual. At normal load, the production per square foot of ground space occupied by the boiler is 94 lbs. per hour from and at 212 degrees with factor 1·13. If the economisers be included, the production is 56 lbs. per square foot, taking the maximum width by the maximum depth. Since the height required by a boiler is also very important, it will be interesting to note that in this case the height to top of the drum is only 15 feet, so that the normal capacity is about 6 lbs. per cubic foot of boiler space, and about 3·6 lbs. per cubic foot, including the economiser and downtake flues.

Referring to Fig. 2 illustrating Niclausse boilers recently set to work at Rotherham, these are again type " B " brickset but single and with superheater located above instead of amidst the boiler tubes. The capacity of each is 25,000 to 33,000 lbs. per hour actual. At normal load, the production per square foot of ground space occupied by the boiler is 95 lbs. per hour from and at 212 degrees with factor 1·13. If the economiser, flues, fan and chimney be included, the production is 53 lbs., figured as before, on gross area. The height is again relatively low, so that the capacity per cubic foot of space is similarly favourable.

Referring to Fig. 3 illustrating the St. Pancras boilers, these will be also the " B " type, but steel encased, and having integral superheaters and steel tube economisers overhead. The capacity will be 40,000 to 50,000 lbs. per hour actual each when fired with coal of 10,500 B.T.U. At normal load, and with a considerably lower factor of evaporation than that of test No. 2 in paper the production per square foot of ground space will be 134 lbs. from and at 212 degrees. The height to top of economiser gas outlet is only 21 feet which is probably considerably less than for other types of boilers.

As regards ground space occupied by test No. 2 boiler, the

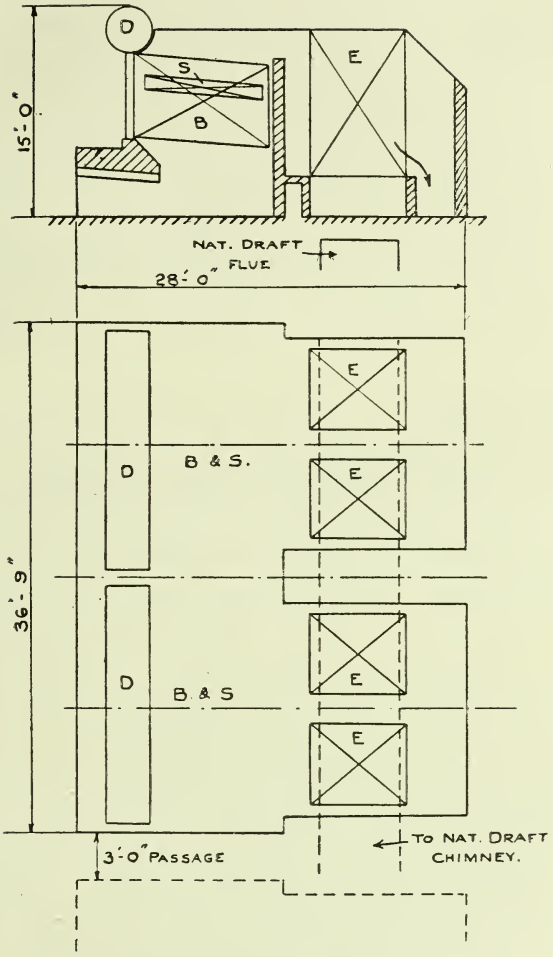


FIG. 1.—NICLAUSSE TYPE B22 BRICK SET.
BATTERY OF 2.
Grate Area = 180/150 *sq. ft.*
Capacity each.—22,500 *lbs. per hour actual.*
Capacity each.—28,000 *lbs. per hour from and at* 212.
Area 1,030 *sq. ft. Height* 15 *ft.*
Production per sq. ft. of ground space. Boiler = 94 *lbs.*
Production per sq. ft. of ground space. Boiler and Economiser = 54 *lbs.*
Production per cub. ft. of space. Boiler = 6·0 *lbs.*
Production per cub. ft. of space. Boiler and Economiser = 3·6 *lbs.*

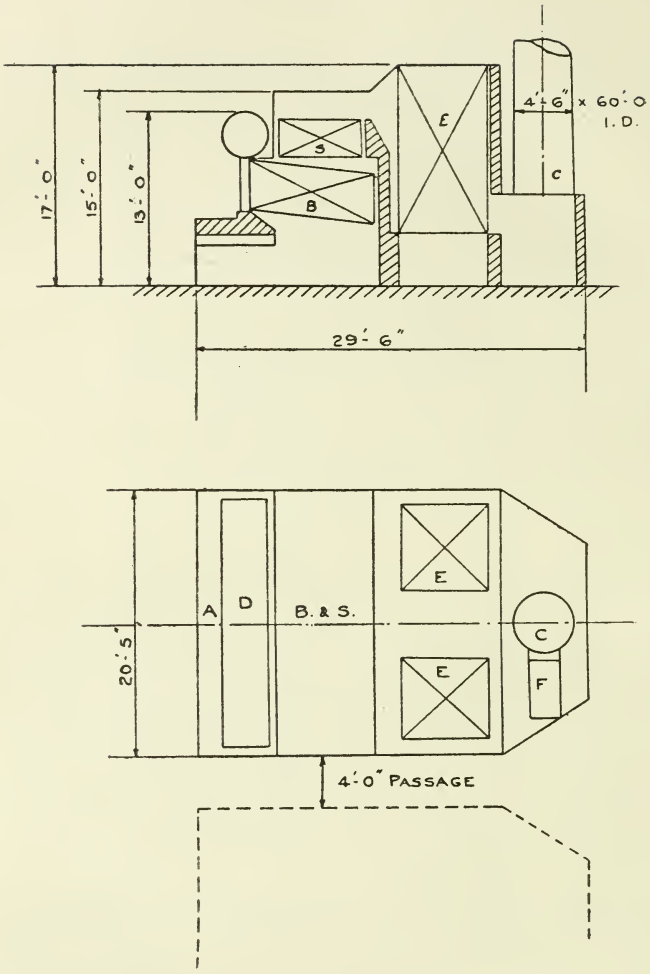


FIG. 2.—NICLAUSSE TYPE B18 BRICK SET.
Grate Area = —/148 sq. ft.
Capacity.—25,000 *lbs. per hour actual.*
Capacity.—33,000 *lbs. per hour from and at* 212.
Area = 605 *sq. ft. Height* 15 *ft.*
Production per sq. ft. of ground space. Boiler = 95 *lbs.*
Production per sq. ft. of ground space. Boiler, Economiser, and Fan = 53 *lbs.*
Production per cub. ft. of space. Boiler = 6½ *lbs.*
Production per cub. ft. of space. Boiler, Economiser, and Fan = 3·5 *lbs.*

figure 384 square feet given, appears to include the part of the stoker which projects beyond end of the arch, whilst for the boiler in No. 1 Test, the area given seems to be the nett space occupied. He asks the author to explain, and in his reply to set forth the capacity per square foot of nett space ? Apparently the nett ground space occupied by the Marine type boiler having overhead steel tube economiser, Appendix IV, is 326 square feet, figured on the basis of depth to end of stoker arch multiplied by extreme width which Mr. Lewis has taken,* giving a from and at production per square foot of ground space of 111 lbs. with the high factor of 1.345 and falling short of the Niclausse "B" type St. Pancras boilers, whose test efficiency will correspond.

In regard to passage requirements, the Niclausse does not require any passage way at the back. Moreover, its sooting lance needs operating *only* from the front, and if the Niclausse stoker be applied, no poking from either the sides or the front is necessary, therefore the side passages may be less than is essential with other boilers. The lance cleaning may be substituted by internally fixed steam jets, an alternative device that Niclausse developed, but abandoned years ago as not being so effective and worth the complication involved.

Referring to Fig. 4 illustrating a 50,000 to 62,500 lbs. per hour actual "B" type encased boiler, having brickset C.I. economisers with induced or natural draft chimney in the rear as proposed for Manchester, the productions on nett ground space for boiler and boiler plus economiser with its flues, chimney and draft fans, are respectively 128 lbs. and 61 lbs. per square foot per hour from and at 212 degrees again taking maximum width and depth. Obviously, bearing in mind that the Niclausse stoker does not require more than 16 feet width of firing floor, eight such units could be installed with economisers, chimneys, etc., on ground floor in a single floor boiler house but little larger than the double floor house indicated in Fig. 1 of the paper, *i.e.*, instead of 80 feet wide × 149 feet over pump house

* Since the amount of stoker projection beyond the front of a boiler or beyond the end of the furnace arch varies with different types and designs of stokers, Mr. Lewis considers it better to take as the boiler floor space the product of extreme width into the depth as measured from the back to the end of the stoker arch, than to measure the depth as being over the part of stoker projecting furthest into the firing floor space.

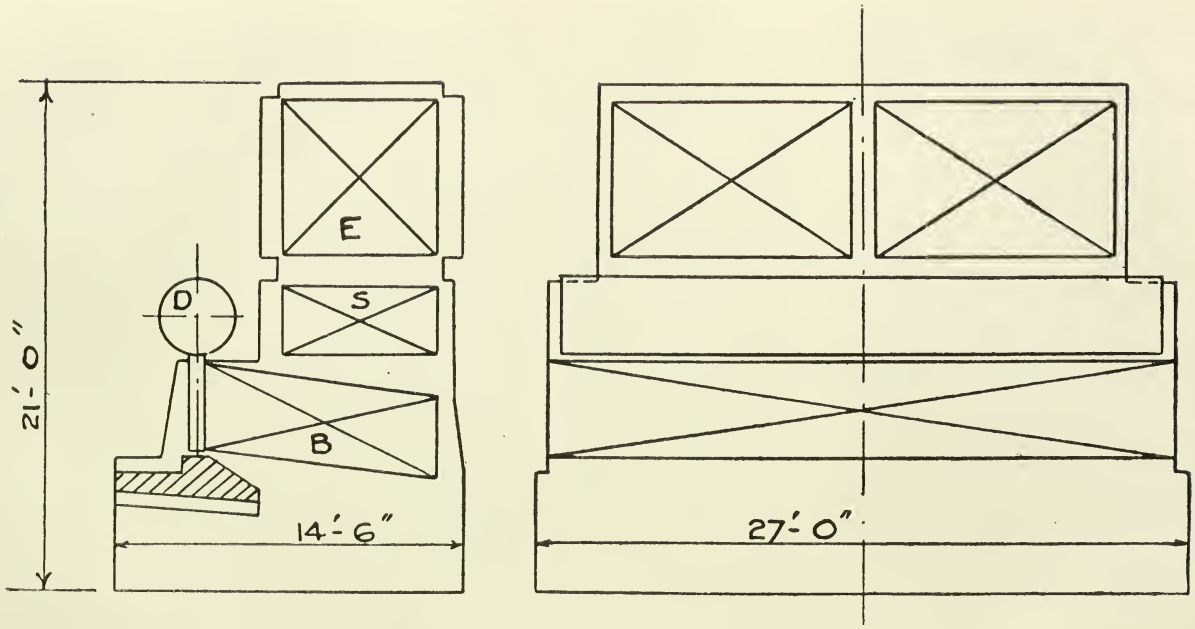


FIG. 3.—NICLAUSSE TYPE B18. ENCASED. S. T. ECONOMISER.
Grate Area = 286/240 *sq. ft.*
Capacity.—40,000 *lbs. per hour actual.*
Capacity.—52,500 *lbs. per hour from and at* 212.
Area = 392 *sq. ft. Height* = 21 *ft.*
Production per sq. ft. of ground space. Boiler, Superheat, and Economiser, 134 *lbs. per hour.*

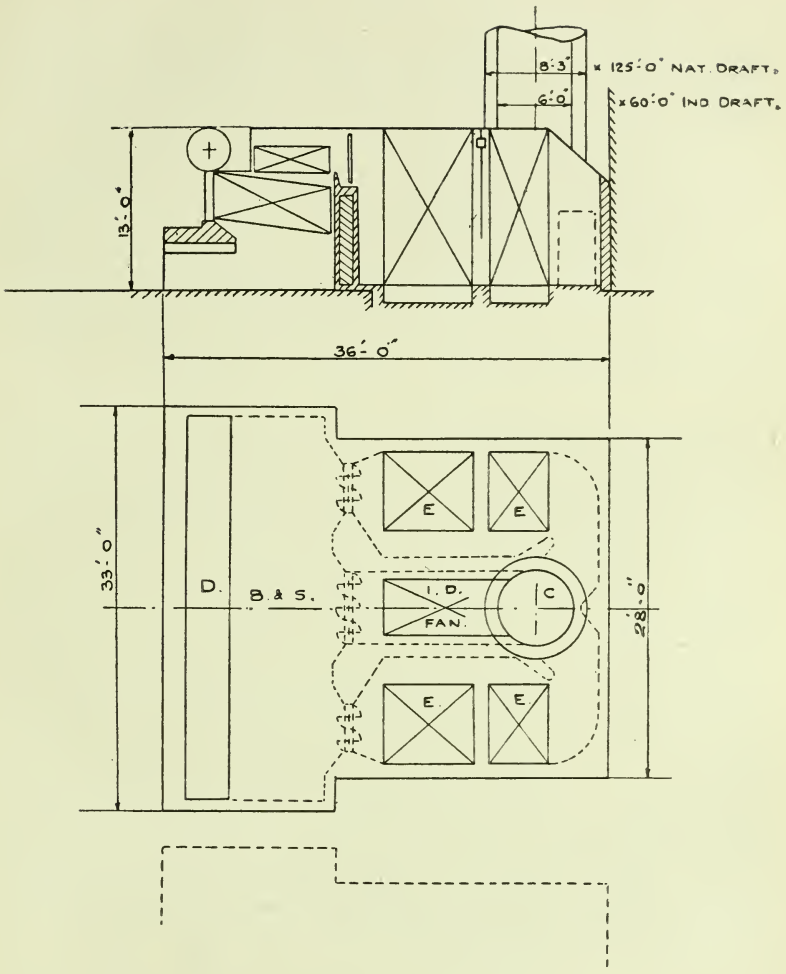


FIG. 4.—NICLAUSSE TYPE B18 ENCASED.
Grate Area = 340/300 *sq. ft.*
Capacity.—50,000 *lbs. per hour actual.*
Capacity.—67,000 *lbs. per hour from and at* 212.
Area = 1,100 *sq. ft. Height* 13 *ft.*
Production per sq. ft. of ground space. Boiler = 128 *lbs.*
Production per sq. ft. of ground space. Boiler, Economiser and Fan =61 *lbs.*
Production per cub. ft. of space. Boiler = 10 *lbs.*
Production per cub. ft. of space. Boiler, Economiser, and Fan = 4·7 *lbs.*
If Economisers be arranged without Bye-pass Flues shown, the depth would reduce to 33 *ft.*

it would be (if economisers had bye-pass flues) roughly 88 feet wide × 171 feet over pump house, but having no overhead flooring for economisers. Where circumstances permit this arrangement warrants consideration, since the saving in cost of structural steelwork would be a factor of importance. In this case, the total ground space for eight boilers, economisers, chimneys, fans and firing floor, would be (151 × 88) = 13,288 square feet of which 9,504 square feet or 71 per cent., is boiler and economiser space. The effective grate area per boiler being 300 square feet, or a total of 2,400 square feet, is 18 per cent. of the total ground space. It should be noted that relatively large grate area has always been an important feature of Niclausse practice.

Fig. 5 indicates these same 50,000 lbs. per hour "B." type encased boilers set back to back, with encased instead of brickset C.I. economisers located overhead, and induced draft chimneys between economiser banks as shown. This arrangement gives the boiler house only 44 or 45 feet wide, as shown in Fig. 6, and would be suitable for turbines of 30,000 kw. requiring such pitch. Alternatively, for 15,000 kw. turbines at 38 or 39 feet pitch, desired by the author, the Fig. 7 shows an arrangement of four boilers on each side of the turbine house feeding right and left hand turbine from alternate sides. The shape and low height of the Niclausse boiler permits of excellent day-lighting being ensured from skylights to the firing floors. The diagrams indicate a good light space between economiser casing and coal bunkers. As regards cleanliness and ease of operation and maintenance of Niclausse equipments experience proves that upon these points they have important advantages—resulting in less necessity for the provision of spare boiler plant. As regards high pressures and high superheat, Niclausse boilers have been built for 500 lbs. per square inch and superheaters for the highest degrees demanded.

Adverting to Fig. 5, 6 and 7 in these cases, the total ground space occupied by the boiler house of 400,000 lbs. per hour actual capacity is (45 × 162) = 7,290 square feet, of which 3,696 square feet or 50 per cent. is occupied by the boilers, having 2,400 square feet of effective grate area, that is 65 per cent. of boiler floor space, or 33 per cent. of the total boiler house ground space. In making comparisons, the relative height should not be overlooked—indeed the cubic content is a very

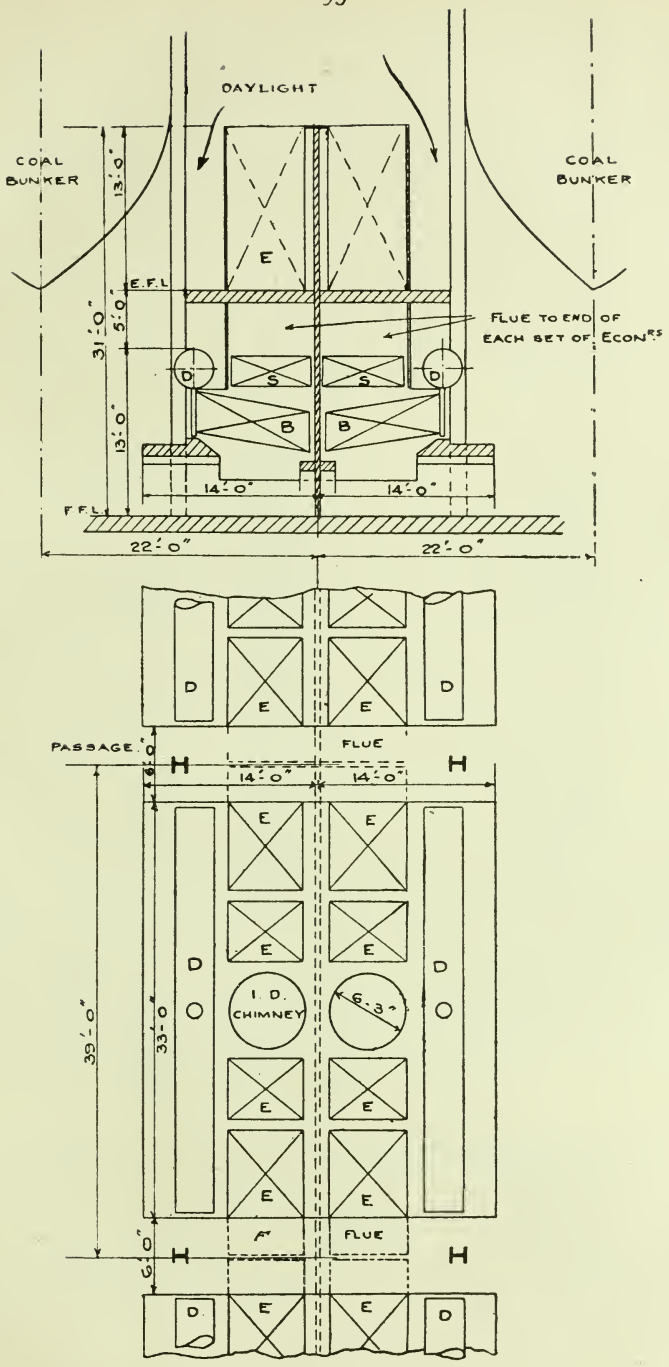

DAYLIGHT
COAL BUNKER
COAL BUNKER
13'-0"
E.F.L
5'-0"
31'-0"
13'-0"
E
FLUE TO END OF EACH SET OF ECONRS
D
S
S
D
B
B
14'-0"
14'-0"
F.F.L
22'-0"
22'-0"
D
E
E
D
PASSAGE
FLUE
H
H
14'-0"
14'-0"
E
E
E
E
D
D
I. D. CHIMNEY
6'-3"
E
E
E
E
39'-0"
33'-0"
6'-0"
FLUE
H
H
D
E
E
D

FIG. 5.

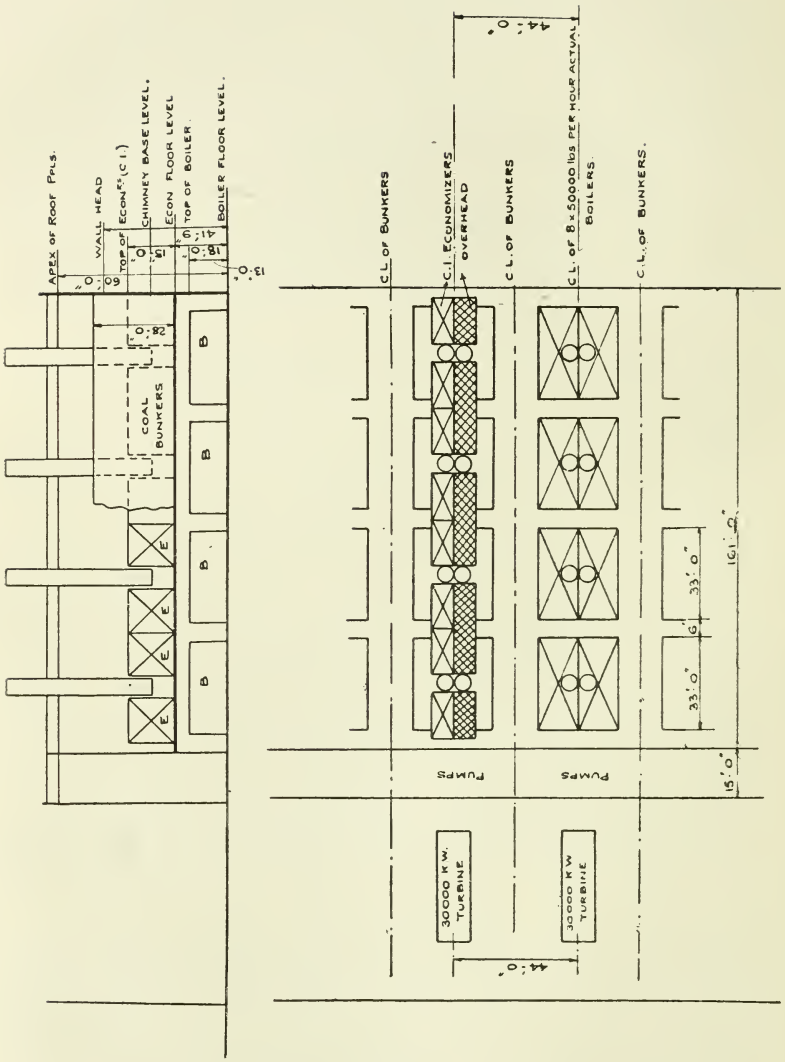

APEX OF ROOF PINS.
WALL HEAD
TOP OF ECONRS (C.I.)
CHIMNEY BASE LEVEL.
ECON FLOOR LEVEL
TOP OF BOILER
BOILER FLOOR LEVEL.
13'-0"
COAL BUNKERS
C.L. OF BUNKERS
C.I. ECONOMIZERS OVERHEAD
C.L. OF BUNKERS
C.L. OF 8 × 50000 lbs PER HOUR ACTUAL BOILERS.
C.L. OF BUNKERS.
44'-0"
161'-0"
33'-0"
33'-0"
15'-0"
PUMPS
PUMPS
30000 K.W. TURBINE
30000 K.W. TURBINE
44'-0"

FIG. 6.

important factor, since it is indicative of the amount of brickwork, tubes, etc., and the weight thereof to be supported and afterwards maintained. The best steam generating equipment is that which has the least volume and weight, other factors being equal, especially as lower volume and weight certainly ensure better operating results. This is evidenced by recent advocacy by other makers of their short tube marine type boiler in preference to their long tube land type, and steel tube in preference to the C.I. type economisers. Obviously, therefore, the Niclausse equipment indicated in Fig. 3 comprises best modern practice.

As regards efficiency the Niclausse "B" type brickset with C.I. economiser as in Fig. 2, can easily attain 80 per cent. on 6 hour test. The "B" type, encased, and having encased steel tube economiser as in Fig. 3 will similarly give fully 84 per cent. when fired with 10,500 B.Th.U. fuel. The important criterion, however, is not efficiency on a short run test as given in the paper, but *average efficiency* over say a year's working, and in this direction there will be found many features of the Niclausse equipment proving its advantages. He observes that the test records given in the paper are presented in the stereotyped fashion set forth in "Steam," which in no case gives sufficient data to permit checking. The late Professor Smith, in a recent mathematical investigation of similar boiler tests taken from that publication, found that four out of nine showed the efficiency of the boiler above to be over 100 per cent. In the Inst. Mech. Engineers Paper on Niclausse Boilers delivered in July, 1914, tests of the more modern "M." type high duty boiler are given in complete detail together with heat balance sheets properly established on the lines laid down by the Inst. of Civil Engineers. The balance sheet cannot be established in any other way, and he then invited other boiler makers to follow suit. He re-invites now the author or the makers of the boilers, of which tests are given in the paper, to produce records in the corresponding correct manner.

The author is correct in pointing out that the production per square foot of ground space is limited by the grate area it is possible to get practically under the evaporating surface, but the limits are considerably beyond the productions set forth. The Niclausse "M" type boiler has attained on 16-hour trials at hourly combustion rates of 20 and 46 lbs. of coal per square

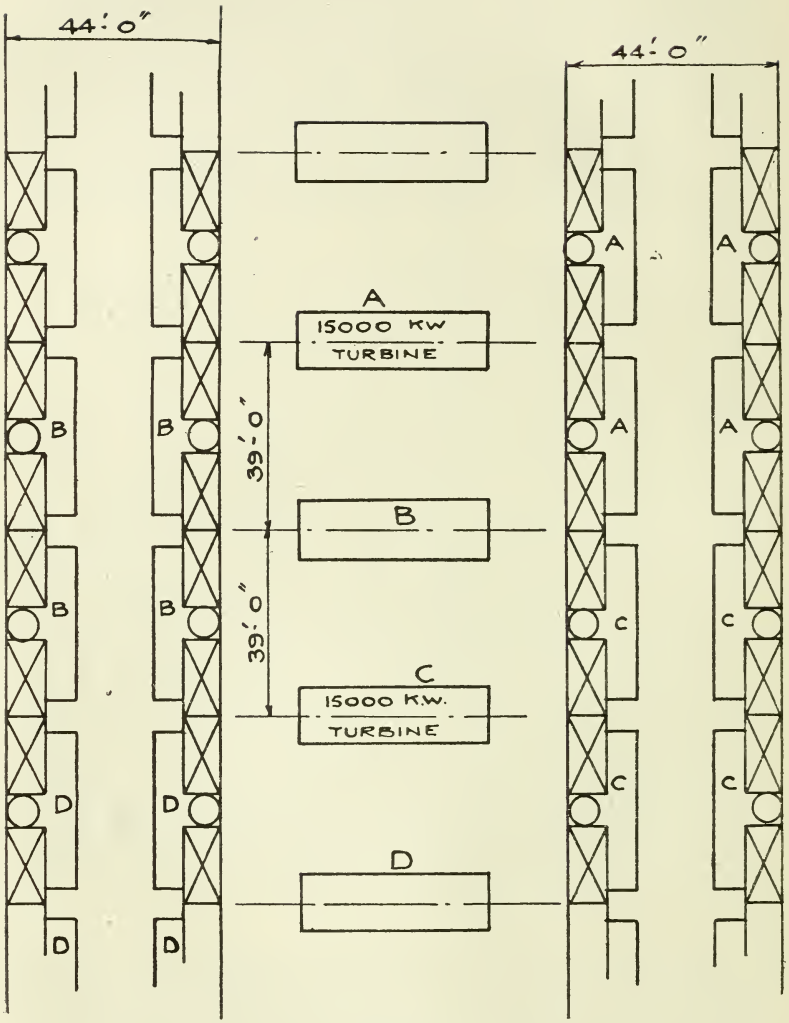


Fig. 7.

foot of grate area productions in dry saturated steam of 180 and 355 lbs. from and at 212° F. per hour per square foot of ground space occupied and at efficiencies higher than those set forth in the paper test (Appendix IV). In respect of grate area, Niclausse practice has great advantages—the boiler is wider and shorter than others—and the entire nest of tubes is placed immediately over the exceptionally large grate area obtainable. What is equally important is that the tubes can be located closer to the grate. The circulation being positively in one (and that the correct) direction only, and the supply of purified feed at steam temperature being abundant—especially to the lower tubes—permits this without fear of tube trouble at highest furnace temperatures. In other types of boilers, circulation is not positively in one direction, so that surging takes place, enabling big blocks of steam to occupy the interior of the tubes instead of water, with distressing results. It is probably for this reason that, according to the author, there is a tendency to increase the height of the combustion chamber space. There is no such tendency in Niclausse practice, a distance of 4 feet between grate bars and lowest row of tubes is not too little for 14 per cent. CO_2 combustion of either coal or oil fuel. (*See* Inst. Mech. Engineer Paper referred to above.)

Mr. C. M. Shaw (Member) (Worcester) (*communicated*), says all are agreed that Turbo-generators justify boiler-plant that gives the maximum steaming capacity in the minimum of space ; and Mr. Lackie's practical and suggestive paper shows what is practicable when employing chain-grates. But the paper says nothing about the recent and very striking developments in firing methods which have accompanied the development of Turbo-generators, whereby the capacity of all types of water-tube boilers can be enormously extended.

At Worcester Electricity Works, although their unit capacity is only 1,500 kw., they have adopted the latest development in firing methods, with the double object of burning cheap fuels such as smudge and pit refuse without loss of steaming capacity, and also of doubling the output of our boilers with a given class of fuel, if burning the class of coal that was necessary for chain-grates.

The stokers are British-made, and are of the multiple-retort entirely underfeed type, having no grates, and therefore burning

the finest coals without any appreciable riddlings ; they are of very simple and robust design, and are fully automatic, having reciprocating tuyeres that continuously slice the fires and discharge the ash automatically.

The boilers are land-type Babcocks, with only 3,140 square feet heating surface, the 4-retort size, easily burning one ton fuel hourly are used. No arches are used, as the thick bed of fuel forms its own combustion arch ; and the positive fan draught assures maximum thermal efficiency at light, medium or heavy duty, thus eliminating banked fires.

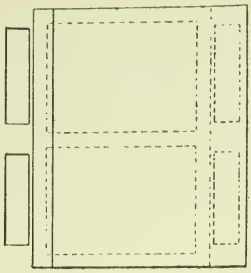
Having already had six months' experience, covering about 2,400 steaming hours, they find very great advantages in flexibility, and in range of fuels, over the chain-grate stoker it replaced ; and this British-made stoker is being adopted for different makes of boilers in numerous central stations.

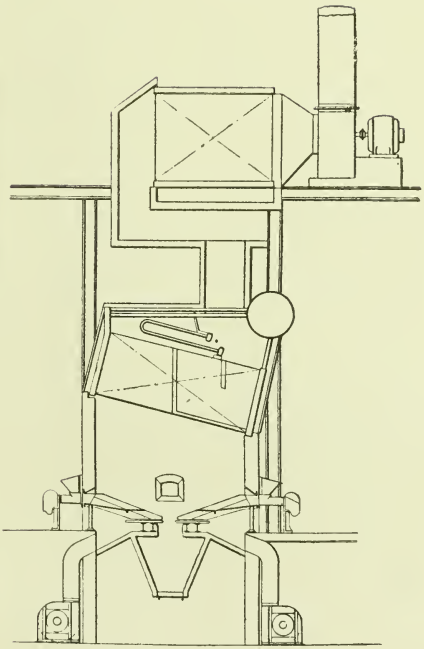
For instance, the 10-retort size of this stoker is adopted for the new Westbank Station of the Edinburgh Corporation, for Stirling boilers each to evaporate 40,000 lbs. superheated steam hourly. This involves about $2\frac{1}{2}$ tons coal hourly, which is burnt on an undivided furnace, at the same easy rate of combustion of 5 cwts. per retort as at Worcester. Each retort is 12 square feet area, but there are no grates ; and with the entirely underfeed combustion involving thick fires, 50 lbs. coal per square foot is much more easily maintained than is 25 lbs. per square foot on chain-grates with their thin fires. There are no arches to maintain, and as the capacity per square foot is so great, there is no necessity to adopt a type of boiler having furnace extending the whole length of the boiler.

The most remarkable development of this modern firing method is in the new plant of the Buffalo General Electric Company, where there are five Babcock boilers each with superheater and overhead economiser, as shown in section on plan.

Each boiler has only 11,400 square feet heating surface, but has capacity for any load up to 10,000 kw., as the boiler, which is a 3-pass cross-drum Babcock, is raised above a double-ended furnace, and fired at each end by a 15-retort continuous-cleaning stoker ; so that, when burning 5 cwts. per retort as in the similar

AMING CAPACITY.





BUFFALO G.E.Co., U.S.A.

TWO BOILERS WITH 4 INCLINED GRATE UNDERFEED STOKERS.

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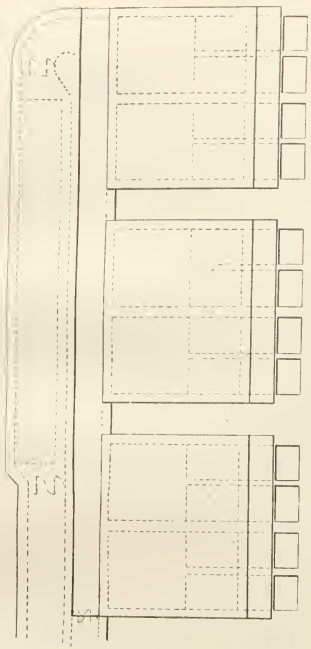
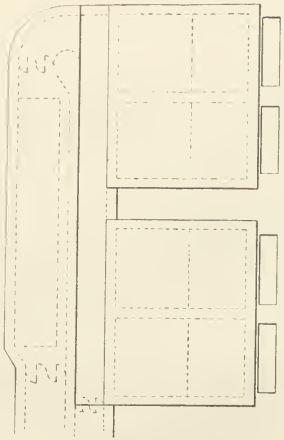
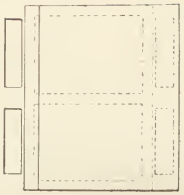
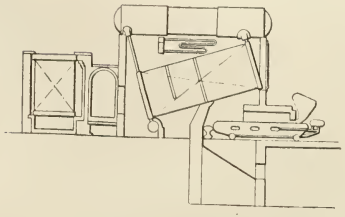
COMPARISON BETWEEN THREE PLANTS, EACH HAVING SAME STEAMING CAPACITY.



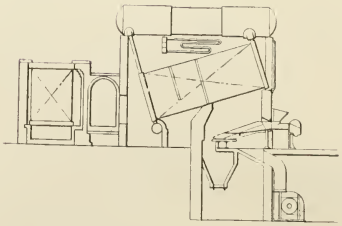




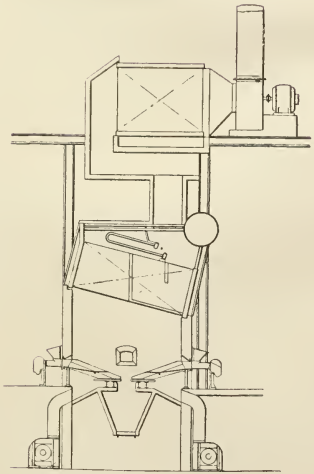


SIX BOILERS WITH CHAIN GRATE STOKERS.

(This diagram to face C. M. Shaw's communication.)



FOUR BOILERS WITH 4 INCLINED GRATE UNDERFEED STOKERS.



BUFFALO G.E.Co., U.S.A.

TWO BOILERS WITH 4 INCLINED GRATE UNDERFEED STOKERS.

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stokers we use at Worcester, the undivided furnace, 25 feet wide and 16 feet deep, suffices for the combustion of 7½ tons coal hourly, without forcing, giving 120,000 lbs. superheated steam with the good coal used.

This boiler-unit, in all but the firing method, is extremely similar to the units shown in the paper for 50,000 lbs. each, corresponding to 3,750 kw.

With the 3 long chain-grates per boiler, as shown in Fig. 3, rear access is requisite, and double-ended firing would not be practicable, even if the extra space were allowable. It is clear, on the basis of test of this type of plant, shown in Appendix IV., that even with washed nuts having only 4 per cent. ash, the normal duty is about 21 lbs., and the two-hour overload duty only 26 lbs. coal per square foot of chain-grates ; so that very long chain-grates are employed, three each to burn one ton such fuel hourly ; so that with the thin fires and overfeed stoking shown, each unit is limited to 3 tons of coal, or say 30,000 lbs. steam ; while in the Buffalo plant, each such boiler is easily capable of two-and-a-half times the duty, in the same area, with the modern firing method as used at Worcester.

These 10,000 kw. boilers at Buffalo, will naturally be compared with the 10,000 kw. boiler units at Detroit, referred to by the author.

While the Buffalo boilers are 3-pass Babcocks with overhead economiser complete, the boiler heating surface being only 11,400 square feet, for 10,000 kw. load ; the Detroit boilers are 5-drum Stirlings, 23,654 square feet heating surface each, but without any economisers, and therefore discharging gases at higher temperature than if economisers were used.

While the Buffalo boilers have two 15-retort Riley stokers each, the Detroit boilers each have two 13-retort stokers of an older type with stationary tuyeres.

In each case, the boiler is placed above an undivided furnace, and fired at both ends ; but whereas the Buffalo boilers pass all the gases through the 3-pass boiler in one direction, the Detroit boilers are of the 5-drum type, but introduce the heat

at the centre, between the two mud-drums, and half the heat flows outwardly in each direction, with only a 2-pass travel.

It is interesting to compare this Detroit practice with the new Edinburgh plant already mentioned, as arranged for 10-retort continuous-cleaning stoker, two-and-a-half times the size used at Worcester, but otherwise identical.

With this British-built stoker, although the cleaning is continuous and not intermittent as in the older types of underfeed stokers, no attempt has been made to follow the mistaken practice of using too few retorts. All sizes are based on the very moderate duty of 5 cwts. coal per retort hourly, which involves only about 1 per cent. working cost for stoker and fan together.

At Edinburgh, for instance, each 10-retort stoker has easy capacity for $2\frac{1}{2}$ tons coal hourly; and as the coal there is only 10,500 B.Th.U. per pound, this corresponds to 35,000 lbs. superheated steam, or 2,500 kw. load for each 5-drum Stirling boiler with 8,500 square feet heating surface, plus economiser.

The ordinary front furnace suffices, and the gases have the usual 4-pass travel over the entire heating surface, and thence through the economiser.

The final temperature of gases will therefore be lower than with the 2-pass gas travel in both directions on the 5-drum double-ended Stirlings at Detroit, which have no economisers.

With an equal quality of fuel, three 8,500 square feet Stirlings as at Edinburgh, each with 10-retort stoker, will naturally do more work than one 23,654 square feet Stirling boiler at Detroit, having two 13-retort stokers of an older pattern.

It is interesting to notice that this conservative British practice, of limiting the duty to about 5 cwts. per retort hourly, is followed in the latest American plant, viz., in the five large-unit boilers at Buffalo, which have two 15-retort continuous-cleaning stokers to burn $7\frac{1}{2}$ tons of 14,000 B.Th.U. coal, and to give 120,000 lbs. superheated steam each, on 3-pass Babcock boiler.

Referring to the tests of boilers with chain-grate stokers, shown in Appendices III. and IV. of the paper, the Port Dundas test with land-type boiler and Scotch peas 10,819 B.Th.U., is noticeable for a much higher rate of combustion with similar draught, than the test evidently made elsewhere of the marine-type boiler with washed nuts 13,045 B.Th.U. The tests are of unduly short duration, but show that the economiser in the latter case heated the feed to only 183 degrees, as compared to 248 degrees in the older plant.

Referring to the illustrations, it is clear that there is no occasion for the extra space and cost for side-window lighting, as per Figs. 4, 5 and 6; since adequate daylight, from roof lighting alone, is admittedly given with the much more compact scheme, Figs. 1, 2 and 3.

But, by adopting a double-ended furnace with a suitable stoker, it is evident that the space and cost of the boiler-plant shown can be cut in half, and the flexibility and range of fuels greatly extended with the more modern type of stoker.

Mr. Lackie, in his reply (*communicated*) says he wishes to thank the Association for the friendly reception given to this paper, and he fully appreciates the value of the discussion and the contributions, both verbal and written, which have been made to it by the various speakers. While the discussion has been of great interest and value, it has largely consisted of elaboration of individual aspects of boiler-house equipment with examples of particular cases, and has therefore only, to a slight extent, traversed the main contentions of the paper so far as these were controversial.

Mr. Fedden drew further attention to the probable load factor on a modern station, and to the importance of coal and ash handling facilities in the design of a new boiler-house. The author has assumed that a modern boiler-house will be called upon to supply steam to a turbine room with a load factor of at least 50 per cent., but the load factor will not alter the design of the boiler-house seriously. He appears to have been more fortunate in his experience with steam flow meters than Mr. Fedden and Mr. Pearce. While the accuracy of these meters may not be within 5 or even 10 per cent., they are a most useful adjunct on a boiler. They have been checked on several occasions when boiler tests were going on, and found quite good practical instruments. Mr. Bowden's experience seems to have approxi-

mated to mine with the steam flow meter. Mr. Fedden has given several valuable costs of coal and ash handling, and the calorific value of different kinds of soots.

The author is of opinion that the outside temperature of a steam pipe covering is no reliable indication of its heat insulating properties. A good covering may have a low outside temperature, but an indifferent covering may have a similar characteristic owing to the rapidity with which it is radiating heat. Conversely a high outside temperature may indicate that the covering is bad, but a good covering, which is conserving the heat efficiently, may also have a high outside temperature.

Mr. Christie's contribution is most interesting, and we will look forward to having the results of his experience of gas firing of boilers with gas from coalite producers. Mr. Wordingham referred to gas firing, as did also Mr. Boot to whose figures the author refers later. Bailie Smith spoke of the experiments which we have been making in Glasgow with producer plant.

Mr. Pearce's remarks are of much practical value, and his arrangement of plant in the new Barton station is extremely interesting. The author's present intention is to have two boiler-houses and then a space equal in width to one boiler-house, and then other two boiler-houses for a station with a capacity of at least 160,000 kw. The space between the two pairs of boiler-houses will be used for the housing of plant which is common to the whole station and which it is difficult to accommodate elsewhere. Assuming that a 15,000 kw. set requires 180,000 lbs. of steam, four boilers each capable of giving 50,000 lbs. of steam per hour will give an ample margin even supposing one of the boilers was off. Three such boilers would meet the demand in an emergency, but one off out of eight steaming two such sets would be easy steaming for the other seven.

Mr. David Wilson's remarks, as was to be expected, are very practical. Thanks to him the author is now able to add a copy of a test on a boiler at Dawsholm gas works, Glasgow, burning gas breeze.

He is indebted to Mr. Selvey for his valuable contribution, and for his correction of some of the figures contained in the paper. The tests included in the paper were, as the author explained, not specially carried out for the paper, but were

records he had beside him, and were included with a view to inducing one or more of the speakers to refer to recent boiler tests.

Mr. Roles referred to the heating surface of certain boilers. The fact is it entirely depends upon where the additional heating surface is placed whether a boiler of 7,000 square feet heating surface or a boiler of 9,400 square feet heating surface will give an equal evaporation. It may mean that the additional 2,000 square feet is simply a feed water heater. Mr. Roles referred to a point which the author would like to hear more about, viz., the increase of steam pressure that is to be looked for.

Mr. Gregory gave some interesting figures of results to be looked for with higher steam pressure and superheating.

The contributions from Mr. A. Dow and Mr. J. W. Parker, both of Detroit, are exceedingly valuable and interesting. The boiler-houses expenses table shows to what extent the detailing of costs is carried in a large modern boiler-house. The total boiler-house costs are just over $\frac{1}{4}$d. (·225d.) per kw. hour, and this is divided into no less than twenty-five separate items.

Mr. Lewis has made a very interesting contribution, accompanied by drawings of arrangements of Niclausse boilers. The scope of the paper does not admit of discussing at length the different types of boilers, but his evaporation figures are noteworthy. The author assumes it is agreed that the maximum efficiency obtainable in a boiler will be the difference between the temperature in the furnace and the temperature of the outgoing gases divided by the temperature in the furnace. It seems, therefore, that unless the temperature in the furnace is raised by more efficient combustion, and the temperature of the outgoing gases lowered by some means (and there is a limit to this), altering the type of casing and economiser will not improve the efficiency beyond a probable stoppage of air leakages.

No one would welcome more than the author the introduction of any means whereby coal could be more efficiently utilised through the extraction of by-products or otherwise. If a supply of waste gas is available let us use it by all means, or if coalite or other smokeless fuel would render gas available at a reasonable figure, as is being tried at Brighton, the electrical engineer would, no doubt, readily take advantage of any such offer. If, however, the line of development is to be by way of the gas firing of boilers, and the production and sale of by-products

other than gas, it seems to him that it is outside both the sphere and the function of the electrical engineer to be responsible for the production and sale of large quantities of coke and other by-products, and we should not be called upon to bear the cost and to suffer the trouble and inconvenience of the experiments which are likely to be necessary for a considerable time to come before the gas firing of boilers becomes a commercial proposition. The author submits that their hands are quite full with their own legitimate business of the generation of electrical energy, and to ask them to undertake work which really belongs to the sphere of the practical chemist and the gas engineer, is simply to lower their efficiency in connection with their own work, and to hamper and hinder the developments in various important directions which all hope and believe are possible if not imminent.

If a ton of bituminous fuel contains say 10 cwts. of smokeless fuel, 3½ gallons of spirit, 4 gallons of refined oil, 4 gallons of crude oil together with a quantity of tar and pitch, and there is only 5,000 cubic feet of gas available for the firing of boilers, it means that if they are to undertake the production and sale of the by-products they will require to handle two to four times their present quantity of coal. With the data at present before us, the author submits that the capital expenditure, additional labour and extra accommodation necessary for gas producer plant, do not warrant the substitution of gas firing for our present method of burning coal direct in the furnace. From a ton of 11,000 B.Th.U. coal we get over 24,000,000 B.Th.U.'s with direct firing. A ton of coal treated as suggested would yield 3,000,000 B.Th.U.'s. So far the author has been unable to make up any balance sheet to show that they are to gain anything by adopting gas firing in a large modern boiler-house. Even on a small scale the results of the experiments are not at all convincing, and there is no evidence to show that with a multiplication of producers there would be any improvement. The annual coal bill of a station using 1,000 tons a day for 300 days in the year with coal at 15s. a ton would be £225,000. To get the same evaporation at least 50 per cent. more coal would require to be burned to destruction in a producer, and the production and sale of 6,000 tons of sulphate of ammonia and 6,000,000 gallons of oil would require to be overtaken. The author estimates that taking everything into consideration the net result would be an increase of 30 per cent. in the working costs of station as compared with the present method of direct firing. If, on the other hand, coal

is used to produce smokeless fuel or coalite it means handling 4,000 tons of coal per day instead of 1,000, and in addition to the production and sale of by-products they would have to dispose of 600,000 tons of smokeless fuel per annum.

In conclusion the author trusts it may be found that the paper has been justified by the excellence of the discussion which it has evoked.

GLASGOW CORPORATION DAWSHOLM GAS WORKS.

Tests with Coke Breeze and Coke.

Boiler.

1. Construction - -	Standard W.I.F., without superheater.
2. Heating Surface -	2,010 sq. ft.

Stoker.

3. Type - - -	Drop link (inclined), with rear arch setting and forced draught. Plain links.
4. Grate area - -	50 sq. ft.
5. Ratio of HS^2/GA -	40·2/1.

General Data.				
6. Date of Test - -	January 27th, 1916.		January 30th, 1916.	
7. Duration of Test -	7 hours.		4 hours.	
Fuel.				
8. Kind used - -	Unscreened breeze.		Screened breeze.	
9. Size :—				
$1\frac{1}{4}'' - \frac{1}{2}''$ - -	26·72%	—	100·00%	—
$\frac{1}{2}'' - \frac{1}{4}''$ - -	35·62%	—	—	—
$\frac{1}{4}'' - \frac{1}{8}''$ - -	24·43%	—	—	—
$\frac{1}{8}'' - 0''$ - -	13·23%	—	—	—
	100·00%	—	100·00%	—
10. Analysis :—	Dried Fuel.	Fuel as delivered.	Dried Fuel.	Fuel as delivered.
Moisture - -	—	23·80%	—	7·64%
Volatile matter -	4·13%	3·15%	5·00%	4·62%
Fixed Carbon -	73·87%	56·29%	79·00%	72·96%
Absolute Ash- -	22·00%	16·76%	16·00%	14·78%
	100·00%	100·00%	100·00%	100·00%

Volatile matter per lb. of Combustile	5·30%	5·95%
11. Calorific value (gross) of dried fuel	10,920 B.Th.U.	11,830 B.Th.U.
12. Calorific value (gross) of fuel as fired	8,070 ,,	10,845 ,,
13. Total quantity fired	10,528 lbs.	4,200 lbs.
14. Consumed per hour wet	1,504 ,,	1,050 ,,
15. Consumed per hour wet per sq. ft. G.A.	30·08 ,,	21·00 ,,
16. Consumed per hour dry	1,146 ,,	970 ,,
17. Consumed per hour dry per sq. ft. G.A.	22·92 ,,	19·40 ,,
18. Riddlings (per cent. of fuel fired)	3·1	—
19. Ash and clinker (per cent. of fuel fired)	—	14·7
Steam.		
20. Quality	Saturated.	Saturated.
21. Average gauge pressure	88 lbs.	92 lbs.
Water.		
22. Feed temperature	41° F.	41° F.
23. Total quantity evaporated	48,700 lbs.	27,000 lbs.
24. Average evaporation per hour actual	6,957 ,,	6,750 ,,
25. Equivalent evaporation per hour from and at 21° F.	8,446 ,,	8,194 ,,
26. Evaporation per sq. ft. H.S., from and at 21° F.	4·20 ,,	4·08 ,,
27. Maximum evaporation for one hour actual	8,500 ,,	7,400 ,,
28. Evaporation per lb. of fuel, actual	4,63 ,,	6·43 ,,
29. Evaporation per lb. of fuel, actual, from and at 212° F.	5·62 ,,	7·80 ,,
30. Factor of evaporation	1·214 ,,	1·214 ,,
Draught.		
31. Kind	Forced.	Forced.
32. In ashpit	+·52	+·45
33. At boiler damper	−·38″	−·39″
Flue Gasses.		
34. Temperature at boiler damper	478° F.	520° F.
34. Average CO_2 at boiler damper	10·4%	9·9%
36. Boiler-house temperature	45° F.	53° F.
Efficiency.		
37. Heat utilised in boiler	67·57%	69·87%
38. Heat lost in flue gasses	14·57%	16·51%
39. Heat lost in radiation and unaccounted for	17·86%	13·62%
	100·00%	100·00%

Remarks.

The tests were carried out in a boiler (without superheater or economiser) before the boiler-house roof was erected, and before the lagging was completed; further, it was raining during the tests and these facts would increase the radiation losses.

The maximum suction draught available at the boiler damper (·41″) was on the low side, and with a higher suction draught better results would be obtained.

The Generation of Electricity on a Small Scale or Bulk Supply.

By HARRY S. ELLIS (*Member*)

(*Borough Electrical Engineer, South Shields*).

Introduction.

IT is the object of this paper to deal with the suggestion of a past President of the Association, Mr. R. A. Chattock, City Electrical Engineer, Birmingham, that "until there is some scheme of centralisation it is extremely unlikely that there will be any marked reduction in the cost of producing and distributing electrical energy below that obtained in the large power stations now operating in this country." These were practically Mr. Chattock's words in his address to the Association at the Birmingham Meeting in 1914, and there is no doubt that many members present regretted that the occasion was not such as would allow of the matter then brought forward by Mr. Chattock being discussed. The purport of Mr. Chattock's address will doubtless be within the recollection of all who read and discuss this paper, but if not it is not a difficult matter to refer to the report of the Proceedings of the Association for 1914 for further particulars.

Mr. Ferranti read a short paper before the Association in 1913 and it is worth while to quote him as follows: "Electricity is being produced on a larger scale every day and it appears certain that to obtain the full benefits of electric

working the current must be produced in large stations supplying extensive areas embracing all classes of demand."

In his inaugural address to the members, etc., of the Institution of Electrical Engineers, the President, Sir John Snell, referred at some length to the subject of centralisation and said : *

" There is no doubt, were we beginning anew, that instead of each small Local Authority putting down an independent power station, considerable waste of money and fuel would be avoided by establishing one large system for several adjacent areas supplying energy to each smaller area for local distribution. Even in some cases where there are existing small power stations, some of them unfavourably situated for cheap generating costs, it would probably pay to extend one of the better placed stations only and to supply the others therefrom rather than to extend each local station from time to time.

" I have a case in point where there are four smaller electrical areas abutting on one larger area, all within a radius of six miles and each having its separate plant. In each of these smaller places the power stations are not favourably situated either for coal supply or for water ; the fifth and largest place, however, has a waterside station. In this case, concentration at the larger station with the consequent advantages of larger units of plant, smaller capital outlay, and cheaper costs of production, would far outweigh the extra costs of transmission cables and transformer plant and the losses in transformation. Unfortunately, however, there are the somewhat narrow views of some of the local engineers and local councils, which prove to be serious obstacles. This is regrettable, for in this particular case the extension of each little system entails waste when compared with the alternative scheme.

" While this is often true, there is, however, another side to the question. It may be generally said that once a small

* *Proc. I.E.E.*, December, 1914, Vol. 53, p. 7.

station is built and the expenditure has been incurred, then, and so long as the system is kept within defined limits of extension, the extra operating cost of an addition to the local power station is often cheaper than any commercially feasible bulk supply. I have had to inquire minutely into many such cases, and in most of them the decision has necessarily been to extend the local plant. No commercial alternative was possible."

The author has quoted Sir John Snell at greater length than he had intended because his words so aptly serve the purpose of a syllabus for this paper. This very important subject, and it is one of great national importance, has been the subject of many addresses to various engineering societies during the past ten years and is an ideal one for such an Association as the I.M.E.A. to discuss, because its members are all concerned, in fact, almost solely concerned, with the question of the generation and distribution of electrical energy, some in a larger degree than others, with the result that some are in a position to take up the cudgels for the smaller Undertakings and others for the larger Undertakings, and therefore the author hopes that however much there may be lacking in this paper there will be nothing lacking in the shape of a thorough discussion of the subject.

This subject has been dealt with by so many people that it is very difficult to avoid going over old ground and it is of such a broad nature that it is impossible to deal with it in more than a general way. It is nevertheless necessary to touch upon some of the more important items which go to make up the cost of generating electricity, which are :

(*a*) Working costs on a large scale.
(*b*) Working costs on a small scale.
(*c*) Capital charges on generating plant in large power stations.
(*d*) Capital charges on generating plant in small power stations.

Working Costs per Kelvin Sold.

With regard to present day " Working Costs," the author would like to draw attention to two tables (Nos. 1 and 2)

which he has prepared with a view to showing definitely the effect of load factor and load on all the items which go to make up what are commonly termed Working Costs. The effect of these factors can be seen at a glance although it might be pointed out that in one or two instances the "costs" increase instead of decrease. For instance, in Table 1 under the heading "Coal" there are two or three cases where the figure for the higher load factor is greater than the corresponding figure for lower load factors. This is due principally to the fact that the number of Undertakings under review is, in this particular instance, small and in many cases include the figures for Metropolitan or South Coast Towns with the natural result that the figure is a high one. However, in almost every instance the costs decrease as the load factor increases and they also decrease as the load increases. The effect of load *and* load factor is shown graphically in Fig. No. 1. This Fig. shows "Total Working Costs" only, but all the other items are affected in like manner, as can be seen on referring to Table No. 1 from which Fig. No. 1 was drawn.

It will be seen that these figures are the result of averaging the costs of several undertakings in each group, and therefore it will be understood that there are instances where the costs in the cases of quite small towns are almost as low as in the case of many of the largest towns—these, however, are more the exception than the rule—and it may be generally conceded that the larger Undertakings can generate more cheaply than can the smaller ones. Table No. 2 takes the case a little further and shows the combined effect of load and load factor on the various items which go to make up the "Total Working Costs."

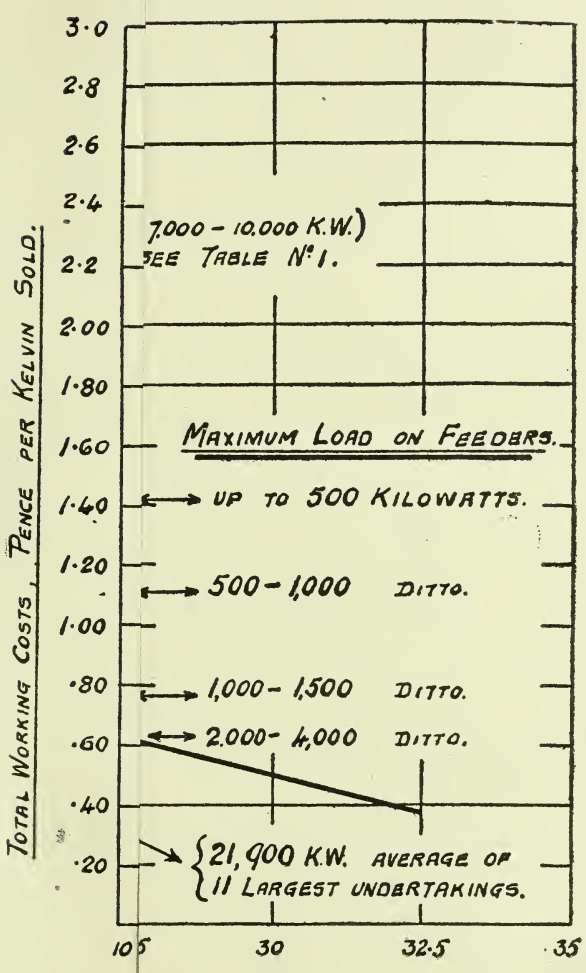
The various items given in the tables are based on *units sold* and not *units generated,* and the item "repairs and maintenance" includes repairs and maintenance in connection with the distributing system. The cost of electricity at the generating station will be dealt with later, when all charges outside the generating station will be left out of consideration altogether.

TABLE NO. I. (*See* FIG. I.)

This table is the result of averaging the figures given in the *Electrical Times* Tables of Electric Supply Costs and Records, and was prepared for the purpose of showing the effect of Load and Load Factor on the Cost of producing electricity.

Load in Kilowatts.	Number of results taken.	Load Factor Per Cent.	Working Costs in Pence per Kelvin Sold.						
			Coal.	Oil, Stores and Water.	Wages of Workmen.	Repairs and Maintenance.	Rents, Rates and Taxes.	Management Salaries, etc.	Total Working Costs.*
Up to 500	13	Up to 15	·7	·08	·32	·34	·18	·5	2·04
	15	15–20	·65	·078	·28	·32	·134	·35	1·82
	6	20–25	·60	·052	·186	·22	·104	·25	1·44
	1	25–30	·67	·06	·27	·17	·09	·16	1·42
500–1,000	6	Up to 15	·6	·05	·18	·29	·15	·26	1·53
	29	15–20	·52	·04	·20	·23	·11	·23	1·35
	16	20–25	·49	·04	·16	·22	·08	·17	1·18
	3	25–30	·51	·036	·14	·23	·04	·11	1·10
1,000–1,500	1	Up to 15	·78	·07	·25	·21	·24	·26	1·81
	14	15–20	·49	·035	·16	·22	·11	·19	1·21
	9	20–25	·33	·023	·126	·18	·07	·124	·87
	2	25–30	·44	·014	·10	·10	·04	·066	·76
1,500–2,000	—	Up to 15	—	—	—	—	—	—	—
	5	15–20	·46	·03	·12	·15	·11	·13	1·00
	5	20–25	·41	·04	·12	·18	·085	·14	·96
	1	25–30	·45	·02	·12	·13	·14	·11	·97
2,000–4,000	2	Up to 15	·39	·03	·12	·24	·01	·12	1·06
	11	15–20	·45	·03	·11	·17	·12	·14	1·02
	17	20–25	·35	·03	·10	·14	·08	·106	·8
	4	25–30	·30	·014	·06	·114	·062	·065	·62
	1	30–	·18	·01	·06	·06	·03	·04	·38
4,000–7,000	2	Up to 15	·45	·034	·12	·21	·13	·126	1·08
	1	Up to 15	·35	·04	·08	·14	·16	·06	·83
	7	20–25	·33	·02	·10	·134	·10	·10	·80
	4	25–30	·27	·013	·06	·09	·07	·06	·57
7,000–10,000	—	Up to 15	—	—	—	—	—	—	—
	—	15–20	—	—	—	—	—	—	—
	3	20–25	·205	·006	·085	·086	·07	·068	·52
	1	25–30	·38	·02	·08	·15	·09	·07	·79
10,000–50,000 (Average = 21,900)	11	25 (Average)	·240	·013	·067	·092	·078	·061	·55

* *See* Fig. I.


TOTAL WORKING COSTS, PENCE PER KELVIN SOLD.
3·0
2·8
2·6
2·4
2·2
2·00
1·80
1·60
1·40
1·20
1·00
·80
·60
·40
·20
7,000 – 10,000 K.W.)
SEE TABLE Nº 1.
MAXIMUM LOAD ON FEEDERS.
UP TO 500 KILOWATTS.
500 – 1,000 DITTO.
1,000 – 1,500 DITTO.
2,000 – 4,000 DITTO.
21,900 K.W. AVERAGE OF
11 LARGEST UNDERTAKINGS.
10·5
30
32·5
35

SOLD.

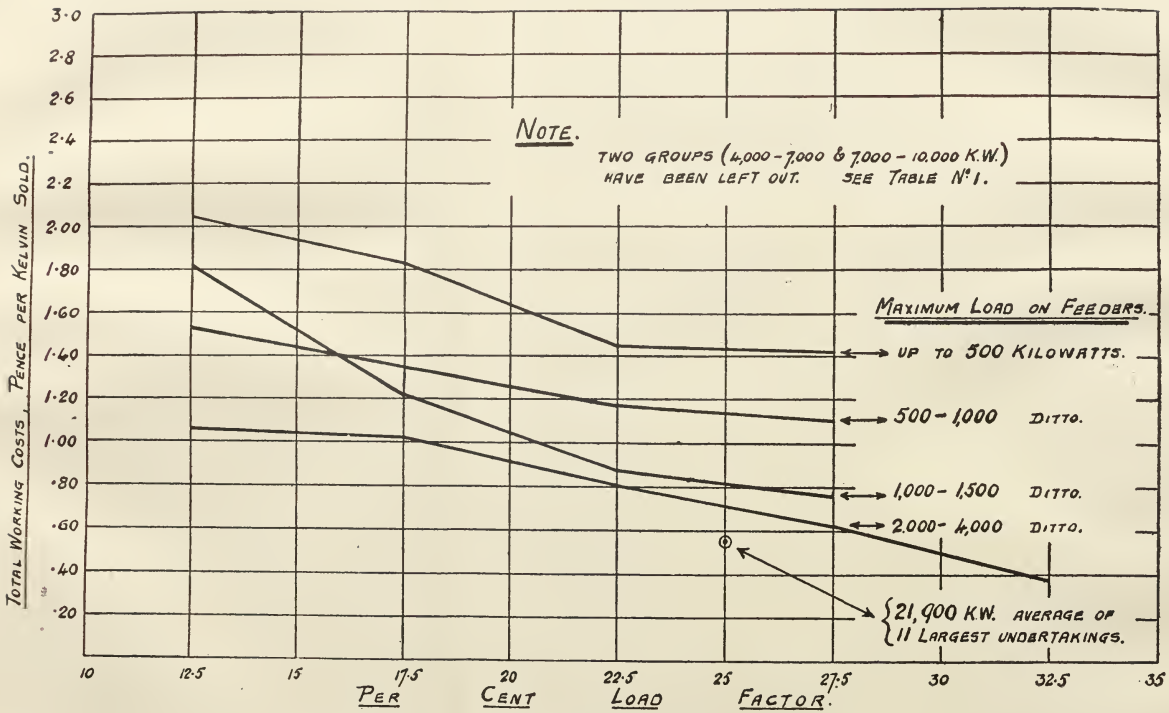


FIG. 1 (*see* TABLE NO. 1).—CURVE OF TOTAL WORKING COSTS PER KELVIN SOLD.

TABLE No. 2. (*See* FIG. 2.)

This table gives the average working costs per Kelvin sold for the various groups of undertakings shown in Table No. 1.

No. of Towns Taken.	Load in Kw.	Total Kelvins.	Load Factor.	Working Costs per Kelvin Sold (Pence).							
				Coal and Other Fuel.	Oil, Stores and Water.	Wages of Workmen.	Repairs and Maintenance	Works Costs.	Rents, Rates and Taxes.	Management Salaries, etc.	Total Working Costs.
35	Up to 500	14,798,276		·65	·07	·26	·29	1·27	·13	·35	1·75
44	500–1,000	64,153,795		·50	·04	·17	·22	·93	·09	·20	1·24
26	1,000–1,500	57,715,963		·43	·03	·14	·19	·79	·09	·15	1·04
11	1,500–2,000	36,162,482		·43	·03	·12	·16	·74	·10	·19	·99
35	2,000–4,000	190,714,163	A.	·36	·025	·096	·144	·625	·08	·11	·82
14	4,000–7,000	145,429,510		·32	·013	·078	·13	·511	·09	·087	·75
4	7,000–10,000	68,784,047		·25	·012	·08	·14	·482	·08	·068	·59
11	10,000 and upwards	538,188,840		·24	·0134	·066	·092	·410	·078	·061	·55
180	Average = 21,900 kw.	1,115,947,076									B.

Note.—A.—No attempt has been made to average the load factor of the various groups because no useful purpose would be served by so doing, but as can be seen on referring to Table No. 1, the load factors vary between about 10 per cent. and 35 per cent. and improve as the output increases, being about 15 per cent. for the smallest, 20 per cent. for the larger and 25 per cent. for the largest Undertakings.

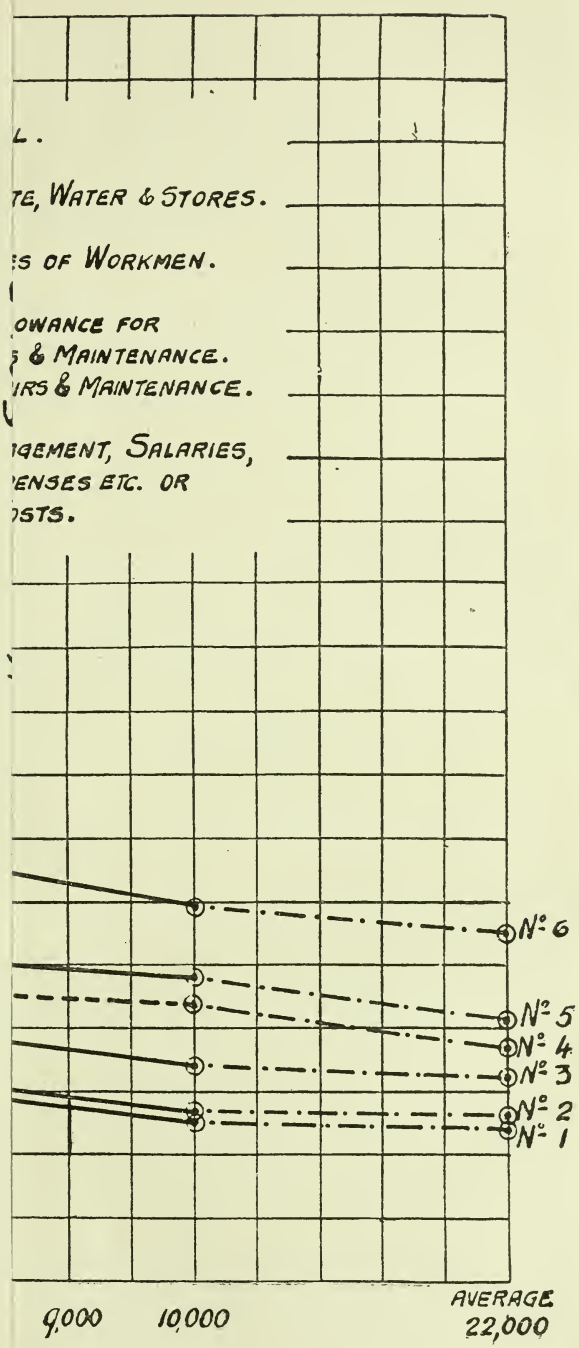
B.—This column does not necessarily equal the sum of the figures given in the other columns, which in most cases have only been given to two places of decimals.

Fig. No. 2 is a curve of the figures given in the above table and shows very clearly the possibilities in the direction of cheap power, but it must not be forgotten that the load factor in no case exceeds an average of 25 per cent. (*see* Table No. 1 load in kws. 10,000–50,000) so that it would appear as if the larger Undertakings had gained very little, compared with the smaller Undertakings, by increased load as far as load factor is concerned.

The best way to improve the load factor of a system is to increase the number of different Industries connected thereto. This however is not always possible, especially in the case of a Municipal Undertaking, whose activities are usually limited to its own Parliamentary boundaries, and perhaps the smaller towns on its borders which may be prepared to take current in bulk rather than to extend their own small generating stations.

The large electrical Power Companies are very much better off in this respect owing to the fact that they embrace very large areas—in some cases including thousands of square miles—thus enabling them to tap all sorts of industries, including railways, tramways, collieries, steelworks, shipyards, ropeworks, flour and jute mills, paper mills and a thousand and one other industries such as are seldom if ever found within the boundaries of any one particular town, however large it may happen to be. On the other hand, the Power Companies suffer owing to the fact that they have to cover a much greater area to secure the same income as would be obtained within the boundaries of a great town, with the result that anything saved owing to improved load factor is to a great extent, if not entirely, swallowed up by the excessive capital charges on the distribution system.

No better example of the generation and distribution of electricity on a large scale is to be found in this country, perhaps in the world, than that to be found in the counties of Durham and Northumberland, where the Newcastle-on-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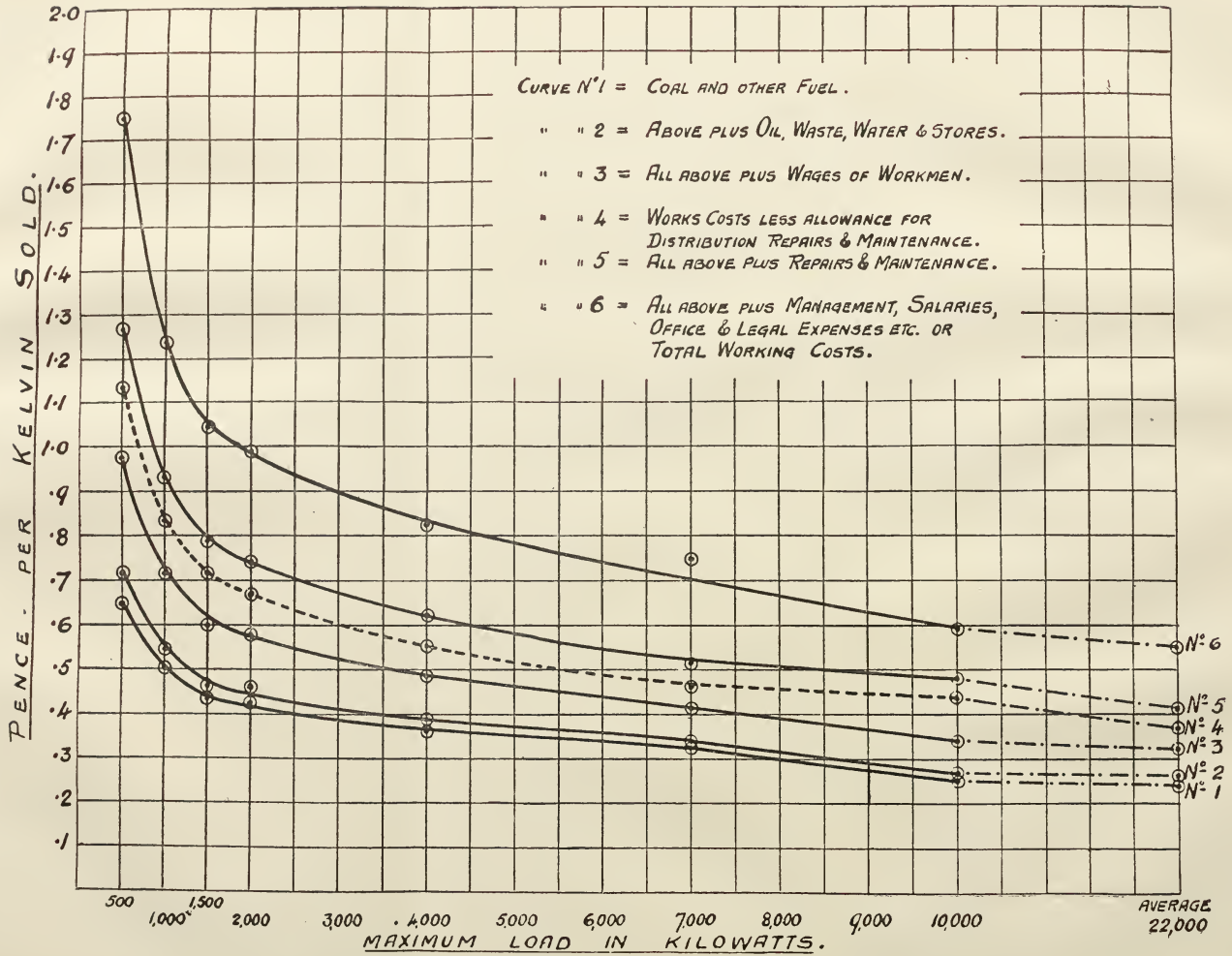

Fig. 2 (*see* Table No. 2).—Curves of Working Costs per Kelvin Sold.
Based on Analysis of *Electrical Times* Tables of Supply Costs and Records.

Tyne Electric Supply Company* and its affiliated Companies operate over an area of more than 1,400 square miles. Some of the Company's generating stations are as much as 30 miles apart, and the output of the several generating stations feeding on to the distributing system varies in some instances between a few hundred kilowatts and 40,000 to 50,000 kilowatts. In some instances a very considerable amount of electrical energy (far exceeding that furnished by many of the larger electric supply undertakings, municipal or company, in this country) is supplied from single generating stations running entirely on waste heat obtained from blast furnaces, coke ovens, etc.

A great deal that might be said about such a Company as this is purposely left out of this paper because the author feels that it is not advisable to say too much at the present time about the importance of any particular Undertaking.

Some years ago the above company tried very hard indeed to persuade the South Shields Corporation to take their supply from the Company instead of extending their own plant, but the engineer at that time (the late Mr. J. H. Cawthra), assisted by Mr. (now Sir) John Snell, appeared to have satisfied not only his Committee and the Town Council, but also the Local Government Board, that by the time proper allowance was made to cover the interest and sinking fund charges on plant already installed —plus the cost of converting the company's extra high tension three-phase alternating current supply to direct current and single phase alternating current—there would be no saving whatever. The Corporation proceeded with their extensions and the results have been entirely satisfactory. Since that time the author has installed and set to work further modern electrical, and also steam generating, plant with the result that still further economies are being effected, and there is every indication that the Undertaking

* Anyone desirous of learning more about the immense business done by this Company should refer to several articles which appeared in *Engineering*, Vol. 91, under the heading "North-East Coast—Electricity Supply," also to p. 7, Vol. 92, of the same journal.

will be in a position to cope satisfactorily with any business that is likely to come along in the future.

Coal Costs.

The most important item, as far as these costs are concerned, is undoubtedly Coal, and a glance at the *Electrical Times* Table of "Electrical Supply Costs and Records" or to the analysis of the same given in Tables Nos. 1 and 2 will show that this item alone accounts in many cases for about half, and in most cases for at least one-third, of the total working costs. The remainder is made up of such items as oil, waste, water and stores; wages of workmen; repairs and maintenance; rents, rates and taxes; and management expenses. It will be seen from the above how necessary it is to deal in detail with such an important item as coal, and it has often struck the author as strange that so much time and thought should be given by Engineers to the question of saving $\frac{1}{2}$ lb. of steam per kelvin and yet practically nothing is done collectively to reduce the price of the coal delivered. As things are at present we are all more or less in the hands of the colliery owners or coal merchants (who are in a position to make or mar our reputations as far as low costs are concerned)—hence the Coal Clause in almost all agreements for bulk supply. Under the present circumstances no Engineer or Committee dare enter into a contract extending over a long period of time for a supply of current "in bulk" without including a clause in the agreement by which the price of electricity supplied is varied to suit a rise or fall in the cost of coal.

If Mr. Ferranti's dream of a national scheme for electric supply is ever to be realised there will have to be some sort of national control over what, in most cases, constitutes the greatest item of cost in the figures for "Total Working Costs" of electric supply. By this it is meant that the colliery will have to be as much a part of the Electric Supply Undertaking as are the generating station and the distributing system. In one case which has come to the knowledge of the author the average price of coal rose steadily

until it reached a figure 30 per cent. higher than that paid thirteen years previously and even then the maximum price to date was not reached because shortly afterwards the effects of the Miners' Strike caused prices to rise still further and they have never been less than the figure referred to. What the effect of the present war will be it is impossible to tell. (*See* Fig. 3.) It is not intended to convey the idea that the author would neglect to do his best to save the $\frac{1}{2}$ lb. of steam per kelvin, but it is intended to emphasise the importance of some sort of joint action being taken by those who control Municipal Electric Supply Undertakings and contemplate the generation of electricity on a large scale to ensure first of all that they can depend, in the future, upon a proper supply of coal at reasonable prices, because there is not the slightest doubt that the inclusion of the Coal Clause in contracts for electricity supply in bulk is, to say the best of it, a very necessary evil.

What is the explanation of the comparatively high works costs in the case of some of our largest and most successful undertakings? It would be interesting to know exactly what is the reason for it cannot be altogether due to the fact that there is still a large percentage of old inefficient plant left in these stations, although this fact no doubt accounts for a good deal of the trouble.

How are these large Undertakings going to justify the supplying of current in bulk at low prices* so long as their coal costs remain in the region of ·25d. per kelvin sold?

There is not the slightest doubt in the author's mind that the steady all-round increase in the price of coal during the past ten or fifteen years has to a great extent, if not entirely, neutralised the effects due to improvements in the design and consequent increased efficiency of steam raising and electrical generating plant and that the lower costs

* By low prices it is inferred that the price would not, in districts where coal can be obtained at a reasonable price, exceed (say) ·375d. per Kelvin for supplies of about 1,000 kw. maximum demand at 28 per cent. load factor, energy to be measured on the primary side of the transformer.

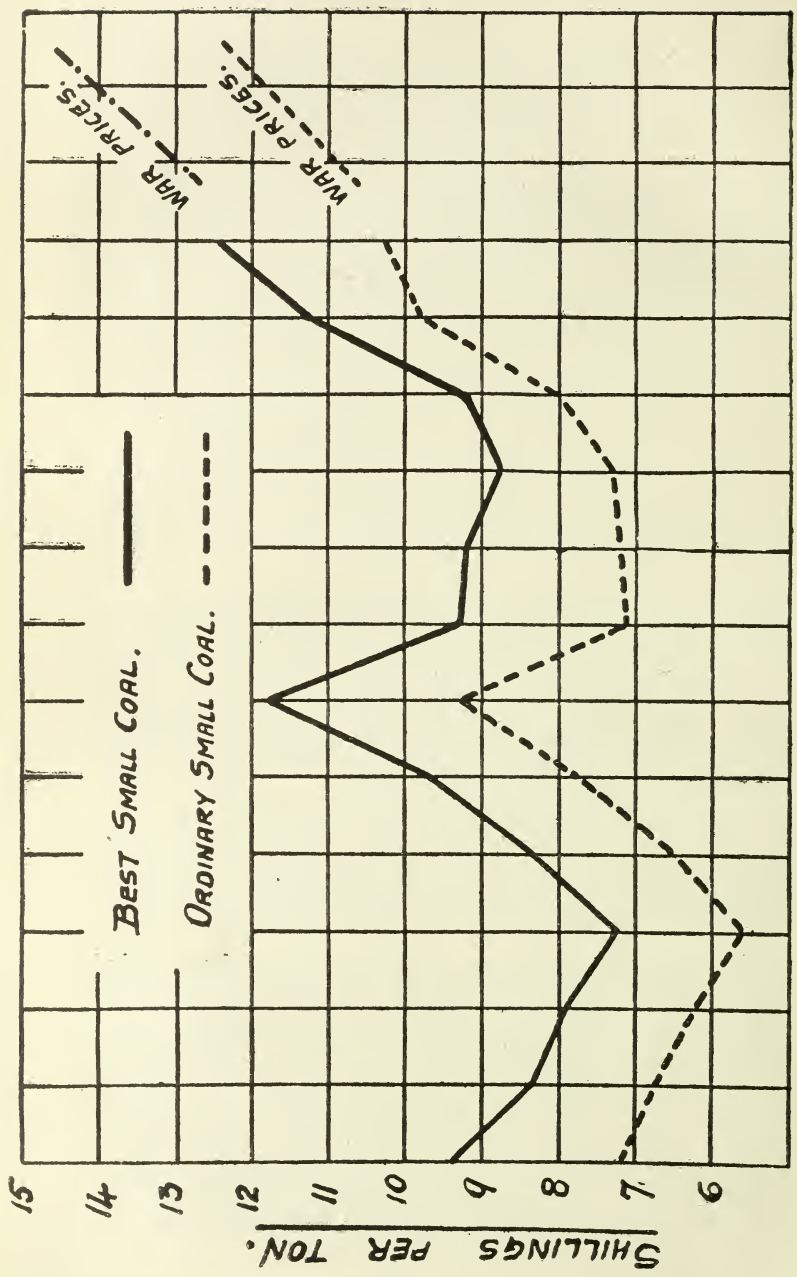

FIG. 3.—CURVES SHOWING AVERAGE MARKET PRICE OF WELSH STEAM COAL, F.O.B. CARDIFF.
The figures were obtained from Mr. Stanley Jevon's book entitled "British Coal Trade" and confirm fairly well the Author's experience of coal prices in the North of England.

obtained have been due largely to the effect of the improved load factor on the other items which go to make up the total works costs.

One of the chief reasons for the steady increase in the price of coal for electricity works is without doubt the wider market which is opening out for the use of small coal and "duff." Years ago "duff" was looked upon as being no good to anyone for the reason that it could not be burnt in ordinary furnaces and consequently there was no market for it. It was therefore cast on one side and used for the making of colliery railway embankments, levelling, etc. For a long time this stuff could be taken away, it might almost be said for the mere asking, or, at any rate, for a very small amount, which was nothing like the amount required to cover the cost of removing it, and the author has heard that in some instances, within the recollection of men who are living to-day, large heaps of what many of us would call small coal were set on fire in order to make room for more of what was considered to be useless fuel. Not so now! It is now made up into briquettes, not only in this country but abroad, and also sold at moderately high prices for use in connection with mechanical stokers for steam raising purposes. Many collieries have spent thousands of pounds on elaborate coal washing plant for the purpose of cleaning this and the higher grades of small coal, such as peas and nuts, with the result that they are now in a position to sell "washed duff," as it is called, at prices very little below the prices of the better qualities.

There is no doubt that in many cases, what might be called phenomenally low costs (such as one hears about and sometimes sees in the *Electrical Times* records), are accounted for not so much through any special features of the plant or load factor or any of the other normal factors governing the cost of generation, but by what is nothing more or less than a mere accident, such as the proximity of the generating station to a coal mine supplying screened coal for household purposes, in which case small coal can be bought for an almost nominal sum per ton.

Cases of very low costs which have come to the author's notice from time to time, and more particularly whilst writing this paper, would appear to be accounted for, partly at any rate, by an accident such as has been referred to in the preceding paragraph.

Most electrical supply undertakers contract for their coal supplies from year to year, and are therefore quite unable to determine what their coal costs are likely to be in the near future. It behoves them, therefore, to be very wary in framing new tariffs for the supply of electrical energy in bulk over a long period and to leave as large a margin as is possible to cover a probable rise in the price of coal.

It does not always follow, of course, that the proximity of the generating station to the coal mine will result in low costs—far from it. The author's experience during the past four years in South Shields has been quite the reverse, for the simple reason that three local collieries within the Borough, belonging to the same Company, and shipping upwards of 2,000,000 tons of coal annually from staiths situated within a radius of $\frac{1}{4}$ of a mile of the electricity works, are unable, or at any rate unwilling, to supply even a small quantity like 10,000 tons per annum, at a price less than that which electric supply Engineers would consider a very high one. The reason for this is that the coal literally drops from the pit mouths into the vessels which take it away to other ports. It is evident, therefore, that Mr. Ferranti's idea about putting down a generating station at the pit mouth is of no use whatever unless the output of the pit is to be used primarily for the purpose of generating electricity or unless a contract be made for supplies over a very long period. The latter course is followed in the case of all Waste Heat Power Stations. In these cases the contract for waste heat to be supplied is probably much longer than the life of the plant installed in the generating station.

It is to be regretted that the editors of our technical papers are not in a position to record as additional to " Coal Costs, Pence per Kelvin Sold," the number of " British Thermal Units per Kelvin Sold, *and* Generated " (which figures could be quite reasonably approximate in most cases where records of the calorific value of the coal used are kept), because this would appear to be the only reliable means of ascertaining whether one Engineer is getting more out of his plant than another. It might even be possible to give the total efficiency of any particular system or of part of it.

It is surprising to note how a Committee or a Board of Directors will discuss at length, and in minutest detail, the question of an increase in salary or wages which does not affect the fifth decimal figure in the total costs figure, and then ten minutes later accept an offer for coal, which materially affects the first decimal figure, without more than a few passing remarks. The reason for this attitude is, of course, obvious to everyone concerned in the buying of coal, namely, that in the one case they have control, whilst in the other they have practically no control whatever. They have to accept the inevitable.

The figures of working costs of Undertakings in the Metropolitan Area are notable examples of the effect of the cost of coal in London, where the record (according to the *Electrical Times* Supply Costs and Records, March 2nd, 1916) for low Total Working Costs in Municipal stations is held by Poplar and Stepney, the figures given being ·51d. and ·58d., respectively, and for coal costs, ·25d. and ·34d., respectively. Although these figures are a record for the Metropolitan Area they are nevertheless high when compared with those of even the smaller provincial stations in the Midlands and in the North of England. The same remarks could be applied, although to a greater extent, to many South Coast towns, which suffer enormously owing to the distance separating them from the coalfields.

Steam Generating Plant.

We now come to that part of our business over which we have, or ought to have, full control. The author has dealt with the question of coal and it is assumed that there is a proper supply of suitable coal at a reasonable price and all that remains to be done is to convert it into electrical energy. It is also assumed that up to this point (the purchasing of coal) the larger Undertakings have little (if any) advantage over the smaller ones. The author is of opinion that this in many cases is an established fact.

The same type of boilers, economisers and all the accessories which go to the making of a modern boiler house can be purchased and installed by a comparatively small Undertaking as well as by the larger ones and for equal load factors it is doubtful whether there is much difference in the relative efficiencies of the large and smaller plants—that is provided the standby plant is proportionate in each case. But this is just where the larger station is likely to gain as the smaller station, working with say two boilers on load, will require a third (equal to 50 per cent. of the total) as standby; whereas, owing to the normal overload capacity of any boiler, the larger station, working with, say ten boilers, can, with safety, run without any standby boiler at all, since in the event of any boiler giving trouble the remaining nine can be overloaded to make up for the faulty one until such time as another boiler is got away. It is evident therefore, that, although the efficiency of the running plant may be the same and very likely is the same in each case, the smaller generating station has a greater percentage of standby losses.

Careful study of several evaporation tests carried out on a number of boilers of the watertube type has satisfied the author that large boilers have very little (if any) advantage over smaller ones from the point of view of efficiency whatever may be their advantages from the point of view of cost, floor space, etc. (There was practically no

difference in the efficiency of boilers having 1,800 and 7,330 square feet of heating surface respectively.) Under normal test conditions it would appear that 78 per cent. is an average efficiency for the boiler and superheater, with about 85 per cent. for the boiler, superheater and economiser, although in one case the efficiency was recorded as being 87 per cent. It must be understood, however, that such high efficiencies as these would only be obtained under very exceptional conditions such as prevail when tests are being carried out and when the boiler is thoroughly clean.

Electrical Generating Plant.

The next matter of importance, as far as the cost of generation is concerned, is the conversion of the energy contained in the steam into electrical energy, which conversion usually is brought about by an efficient arrangement and combination of steam engines, generators and condensing plant. (The term steam engine is intended to cover high-speed reciprocating engines and turbines.) It is not within the scope of this paper to deal with stations running with gas or oil engines, inasmuch as these are, as far as central station work is concerned, more the exception than the rule, and it may be assumed that such plant, except under very exceptional circumstances, affords no advantages over modern high-speed reciprocating engines and turbines.

Figure No. 4 shows very clearly the rapid relative decrease in steam consumption per kelvin of modern high speed turbine plant from sizes of 500 kw. to 2,000 kw., and the remarkably slight fall between sizes of 2,000 kw. and 10,000 kw. It will be seen on referring to this figure that the larger sizes of plants have a gain over the smaller sizes of from 5 per cent. to 15 per cent. It would appear from this curve and other information before the author that where the conditions as regards steam and vacuum are similar the larger stations have had the advantage over the smaller ones as far as the electrical generating plant is concerned, and this is undoubtedly true as regards almost

every make of turbine of the impulse or reaction types or combinations of these types. How long this condition of things will continue it is impossible to say, but from a careful study of results obtained of the very latest type of

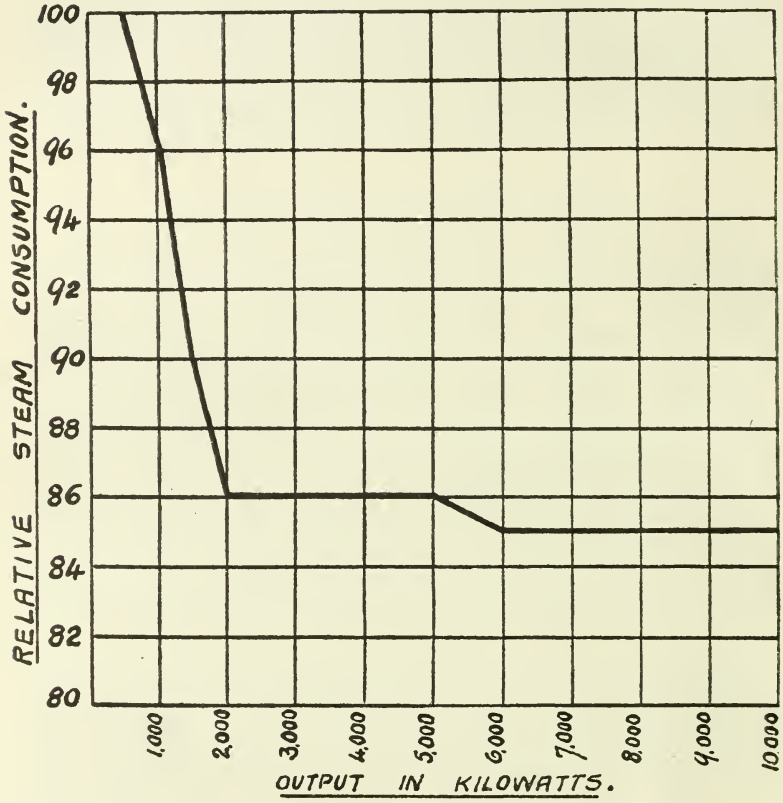

Fig. 4.—Approximate Ratios of Steam Consumption of various Sizes of Turbines.

turbine, *e.g.* the "Brush Ljungström," it would appear that the difference in efficiency of large and small turbines is a factor which is slowly but surely diminishing. This would appear to be primarily accounted for by the fact that it

is almost impossible to get the steam consumption, even of the very largest sets, much below 12 lbs. per kelvin, which figure compares very favourably indeed with 15·5 lbs. per kelvin, which is a fair average figure for the best known types of turbines of about 1,000 kw. output.

The Brush Ljungström Radial Flow Turbine puts a totally different complexion on this matter for it would appear that a 1,000 kw. machine of this type is capable of developing its full rated output with a steam consumption of only 12·75 lbs. per kelvin,* under similar conditions of steam and vacuum to those appertaining to the machines referred to in the preceding paragraph. These results compare very favourably indeed with those obtained in connection with machines of 12,000 and 15,000 kw. capacity, and certainly make one think of the big difference in efficiency which has hitherto existed between large and small turbo generator sets which is fast disappearing.

One of the very largest and most efficient turbines which has ever been built appears to be the 25,000 kw. Set supplied by Messrs. C. A. Parsons of Newcastle-upon-Tyne to the Chicago Edison Company (Fisk Street Station), which Set has the remarkably low steam consumption of 11·65 lbs. per kelvin at full load when supplied with steam at 200 lbs. per square inch, 200 degrees superheat (Fahr.), and with a vacuum of 29 inches.†

Another very efficient set is one of 6,250 kw. installed at the Dunston Power Station of the Newcastle Electric Supply Company in which case the steam consumption on test was but slightly more than in the case cited above.

No better illustration of what the author is anxious to convey can be given than the figures in Appendix No. 1,

* *See* St. Pancras results, *Electrical Times*, p. 399, October 29th, 1914, also App. No. 1.

† *Electrical Review*, p. 871, Vol. 73.

compiled by Mr. Sidney Baynes. Those figures show a difference of only 2·2 lbs. per kelvin between the guarantee figures for a 1,000 kw. and 5,000 kw. turbo set respectively. If the percentage difference between the guarantee figure and the actual figure is the same in each case the figure of 2·2 lbs. will be reduced but it seems hardly likely that the figure of 11·8 lbs. per kelvin will be reduced by so great a percentage as was the figure 14 lbs. per kelvin, namely 9 per cent.; if it is, then the actual figure for the 5,000 kw. set will work out at 10·738 lbs. per kelvin or a difference of 2·012 lbs. when compared with the 1,000 kw. set.

It would appear from the above that whereas large turbines previously had the advantage over smaller ones to the extent of about $3\frac{1}{2}$ lbs. of steam per kelvin they can now only claim an advantage of about 2 lbs. per kelvin or about 15 per cent.

The largest machine of the above type (Brush Ljungström) is now (March 1st, 1916) being erected at Willesden for the North Metropolitan Electric Supply Company—its normal rating being 5,000 kw. at 3,000 r.p.m. and its continuous overload capacity 7,000 kw.

Having referred in detail to the steam consumption of steam turbines it is perhaps only fair to make some reference to the steam consumption of modern high-speed reciprocating engines. The field for this type of plant, not only at present but in the immediate future appears to be among the smaller generating stations where the largest unit is in the region of 750 to 1,000 kw. In such cases a steam engine set capable of developing 1,000 kw. at a speed of (say) 250 r.p.m. will consume at full load about 15·85 lbs. of steam per kelvin when running condensing (26 inches vacuum) and with steam at 180 lbs. per square inch, superheated to 550 degrees Fahr., which figure compares very favourably with those obtained from most steam

turbines of similar output and under similar conditions. The figures for the smaller sets under similar running conditions are briefly as follows: 16, 16·4 and 19·3 lbs. per kelvin for sizes of 750, 500 and 250 kw. capacity respectively. The results at half and three-quarter load exceed the above figures by about 5 per cent. and 10 per cent. respectively. It must not be concluded from the above that the author would condemn the use of reciprocating engines for units exceeding 1,000 kw. capacity but this figure may safely be taken in most instances. There are places where an ample supply of circulating water for condensing purposes is unobtainable without the use of very large and expensive cooling towers and where it would be found cheaper to instal reciprocating engines up to 1,500 kw. rather than to run turbine plant at a low vacuum. In such cases no general rule can be applied and each one must be considered on its own merits.

Total Working Costs per Kelvin Generated.

In order to obtain reliable figures under this heading a further investigation of the figures given in Table No. 2 had to be made and careful consideration given to the records of numerous undertakings set forth in *Garcke's Manual* and as a result the following conclusions were arrived at:

(*a*) From the figures under the heading "Repairs and Maintenance," a figure has to be deducted to cover repairs and maintenance in connection with the distribution system which was found to equal (approximately) 10 per cent. of the figures appearing under the heading "Works Costs," Table No. 2.

(*b*) The distribution losses are (approximately) 15 per cent., which figure can safely be applied to all classes of undertakings both large and small.*

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* (It may be contended that this figure is too high for the larger Undertakings, but as a matter of fact actual calculations prove that the losses in the case of the largest Undertakings slightly exceed 15 per cent.)

When due allowance is made for the above items (*a*) and (*b*) the following figures are obtained :

TABLE No. 3.

COSTS PER KELVIN GENERATED.

Load in Kilowatts.	Works Costs.	Relative Works Costs.	Total Working Costs.	Relative Total Working Costs.	Load Factor.
	Pence.		Pence.		Per Cent.
Up to 500	1·00	100	1·43	100	About 15
500–1,000	·75	75	·996	70	,, 15
1,000–1,500	·64	64	·846	59	,, 20
1,500–2,000	·60	60	·845	59	,, 20
2,000–4,000	·51	51	·668	47	,, 20
4,000–7,000	·42	42	·566	40	,, 25
7,000–10,000	·39	39	·518	36	,, 25
10,000 & upwards	·333	33·3	·450	31	,, 25

A summary of the figures on which Tables Nos. 1, 2 and 3 are based gives the following result (approximate only), which cannot fail to prove of interest insomuch that it indicates the tremendous amount of waste which is—and for years past has been—going on in connection with the generation of electricity :

Kelvins Generated.	Cost of Fuel.	Total Working Costs.
1,300,000,000	£1,438,000 ·265d. per Kelvin.	£3,363,516 ·62d. per Kelvin.

It is not within the scope of this paper to deal with the question of electricity as generated by Electric Supply Companies, private individuals, railways, etc., as well as the municipalities already referred to—which supply probably exceeds many times that indicated above. Had such a thing been possible it might not have been a difficult matter to show how by means of centralisation of supply it might be possible to reduce the above figure, ·265d., by (say) 25 per

cent. (not to mention the total costs figure, ·62d.), and so effect a saving of upwards of £1,000,000 on coal alone. The natural argument against such a statement as the above would be that centralisation could not deal with more than a small percentage of these Undertakings owing to their geographical position. This is a matter for discussion; and such discussion is the real object of this paper.

The author hopes to hear something from those members who are in charge of the larger Undertakings as to how far they are prepared to go towards supplying smaller Undertakings outside their own boundaries and what steps they propose to take to make such a thing possible.

Capital Costs.

This paper must necessarily include some reference to Capital Costs—not only of plant already installed but of plant to be installed—in order to compare figures of the total cost of supplying electricity from large and small power stations. For this purpose reference has again been made to the figures appearing in *Garcke's Manual*. The results obtained are as follows :

Table No. 4.

COST PER KW. INSTALLED OF GENERATING PLANT, LAND, BUILDINGS, ETC.

(Nothing is included for anything outside the generating station.)

Load in Kilowatts.	Cost per Kw. of Generating Plant installed.
	£ s. d.
Up to 500	40 0 0
500–1,000	27 0 0
1,000–1,500	25 0 0
2,000–4,000	22 10 0
10,000 and upwards	20 0 0

The impression created on glancing at the above figures is that the smallest Undertakings have not been able to benefit by the low costs per kilowatt of turbine plant.

This is no doubt a fact, because it has already been shown that below about 1,000 kw., turbine plant does not compare favourably with reciprocating plant as regards steam consumption. Therefore the capital cost per kilowatt in such cases remains high owing to the presence of reciprocating plant. Furthermore, in the case of those stations where turbine plant has been installed, the capacity of the plant installed has been increased by perhaps hundreds per cent. without a single extra pound expenditure on land and buildings. As an example of what this means it may be interesting to make reference to two instances within the author's practical experience, namely :

(*a*) At Bradford, three 3,000 kw. Turbine Sets were installed on a site originally laid out for a 1,000 kw. Slow-Speed Engine Set ; and

(*b*) At South Shields, two 2,000 kw. Turbine Sets superseded three Engine Sets of a total capacity of 400 kw.

The figures in the following tables emphasise the above statements and give one a very fair idea of the future possibilities of generating cheap electricity.

TABLE NO. 5.

COST PER KW. OF GENERATING PLANT INCLUDING TURBINES (OR ENGINES), GENERATORS AND CONDENSING PLANT.

(Foundations, etc., not included.)

Type of Plant.	Kw. Capacity.	Speed R.P.M.	Price per Kw.	Relative Cost (approx.)
			£	
Reciprocating steam engine	250	375	7·5	79
,, ,, ,,	500	300	6·9	73
,, ,, ,,	750	300	7·0	74
,, ,, ,,	1,000	250	7·0	74
Turbine engine - - -	500	3,000	9·45	100
,, ,, - - -	1,000	3,000	5·65	60
,, ,, - - -	1,500	3,000	4·85	51
,, ,, - - -	2,000	3,000	4·3	45
,, ,, - - -	2,500	3,000	3·8	40
,, ,, - - -	3,000	3,000	3·4	36
,, ,, - - -	5,000	3,000	3·0	32
,, ,, - - -	6,000	3,000	2·9	31
,, ,, - - -	5,000	1,500	4·5	48
,, ,, - - -	10,000	1,500	4·0	42

Fig. No 5 shows the above values very clearly, and it will be observed again how the steam engine set holds its own against its competitor in the sizes from about 750 kw.

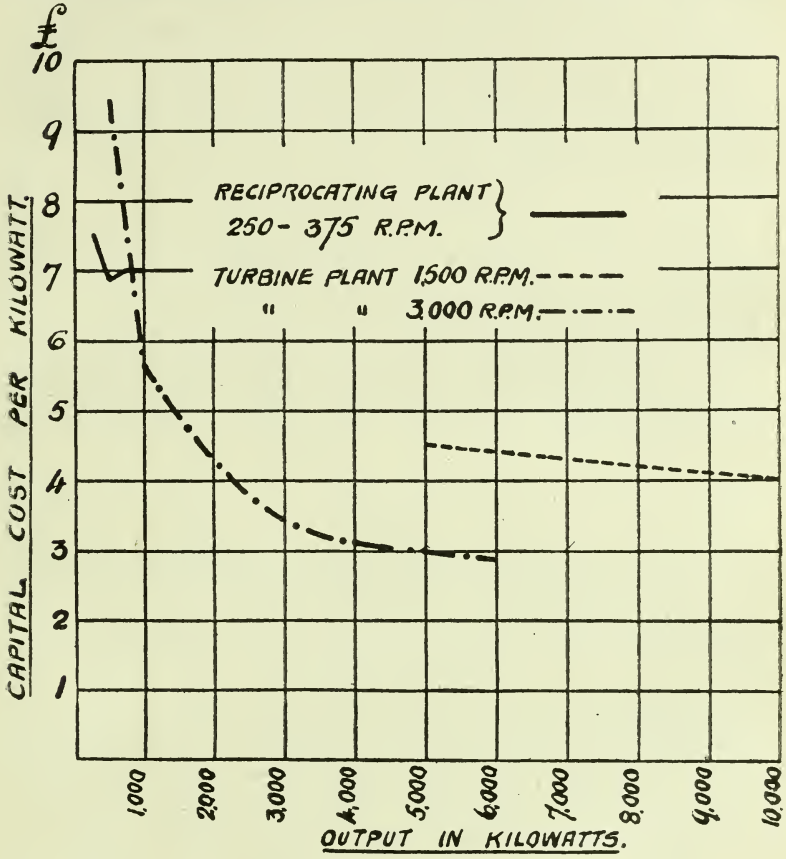


FIGURE N° 5.

CAPITAL COST OF ELECTRIC GENERATING PLANT (INCLUDING TURBINE OR ENGINE, GENERATOR AND CONDENSING PLANT).

downwards. The figures also show that there is nothing gained, as far as the cost per kw. of turbine plant is concerned, by adopting the larger sizes, since owing to the

reduced speed of the larger sets (1,500 r.p.m. as against 3,000 r.p.m.) there is quite an appreciable increase in the cost per kilowatt. Hence, in the case of South Shields already cited, it was possible to instal turbo sets of 2,000 kw. capacity which probably cost no more per kilowatt than the large sets installed in the generating station of the Newcastle Electric Supply Company and without spending a single penny on land, buildings, etc. It is in such cases as these that it will be extremely difficult to make out a favourable case for supplying *in bulk*.

With regard to steam generating plant a glance at the following table and Fig. No. 6 will suffice to show that as far as the boiler-house plant is concerned there is nothing like the same relative difference in cost between large and small units as exists in the case of the engine-room plant although it should be pointed out that the figures do not include buildings, foundations, coal bunkers, conveyors, etc.

TABLE No. 6.

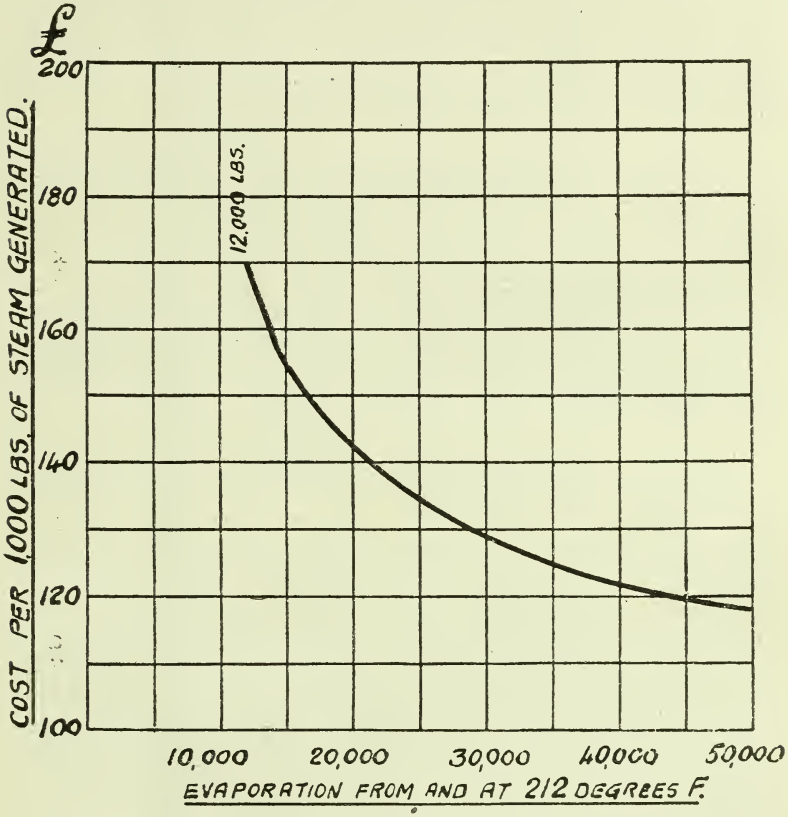
RELATIVE COST OF STEAM GENERATING PLANT INCLUDING BOILER, SUPERHEATER, STOKER, ECONOMISER, BOILER AND ECONOMISER BRICKWORK AND ALL FITTINGS, LADDERS, GALLERIES, DOORS, ETC.

(Steam, 200 lbs. per square inch ; Superheat, 200 degrees F. ; Coal, 12,000 B.T.Us.)

Evaporation from and at 212 degrees F.	Relative Cost.	Cost per 1,000 lbs. Steam.	Cost per Kw.*
		£	£
12,000	100	170	3·4
20,000	84	142	2·85
30,000	77	130	2·55
40,000	72	122	2·45
50,000	69	118	2·35

* All these figures are calculated on the basis of 20 lbs. of steam per kw.h., and they should be corrected to suit any particular cases under consideration in which the steam consumption of the generating plant, auxiliaries, radiation and condensation losses, etc., vary to any considerable extent.

It is unnecessary to go into further detail in connection with the capital cost of various sizes of generating stations because the subject has been written about so often and in such detail that to do so could only result in a waste of time.



Fig, 6.—Capital Cost of Steam Generating Plant including Boiler, Superheater, Stoker, Fittings, etc., Economiser, Boiler and Economiser Brickwork. Foundations not included.

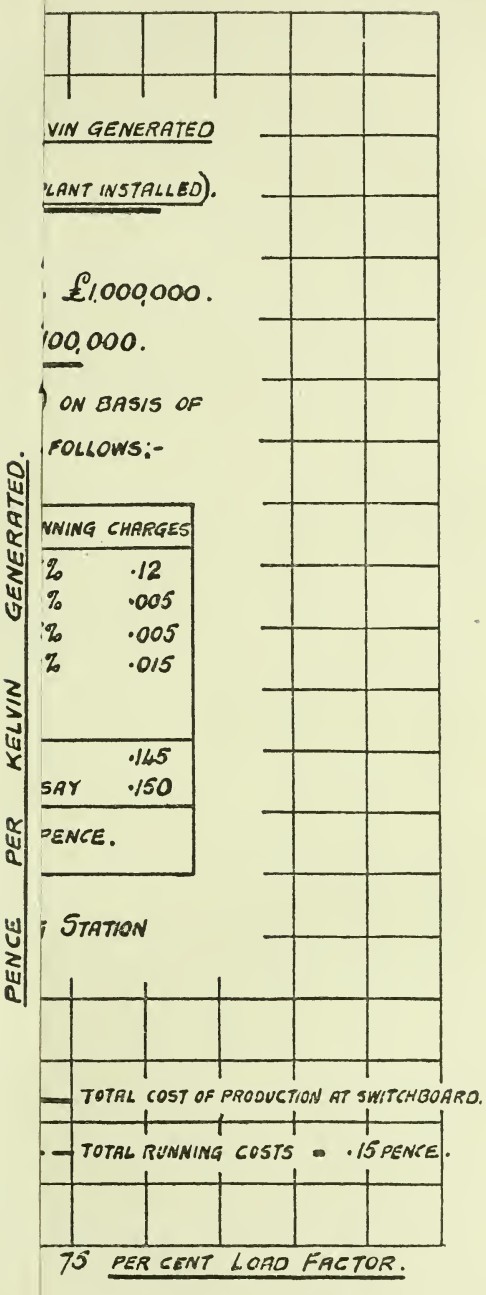
Every electric supply engineer knows that it is quite possible nowadays under normal conditions to put down a very large power station (say 100,000 to 200,000 kw.

capacity) for about £10 per kilowatt of plant installed,* and it is more than likely that this figure might under very favourable circumstances be reduced to £8 per kilowatt. It can also be shown that a small station (say 2,000 kw. to 5,000 kw.) would not cost more than £20 per kilowatt, and a very small station (below 2,000 kw.), £30 per kilowatt. The larger station would have an advantage over the smaller one owing to the lesser proportion of stand-by plant, and also by reason of lower working costs.

Fig. No. 7 has been prepared for the purpose of showing as clearly as possible what might be done, under normal conditions, in the way of generating electricity on a large scale. It will be noticed that in order to have some basis to work on, the figure ·265d. has been taken as being a fair figure for total working costs in a station having a load of 80,000 kw. and a load factor of 25 per cent. This figure is split up into various items of cost which in turn are divided into fixed charges and running charges.

The curve shows the total cost of production at the switchboard only and does not make any provision for capital charges of transmission system, transmission losses, conversion losses, etc. In comparing the figures represented in this curve with the total figures in Tables 1 and 2 it must be remembered that the latter are average figures only and that there are some stations which generate at a cost considerably below the average. Careful investigation, in which proper allowance was made for the capital cost of transmission system, transmission and transformer losses would undoubtedly show that there are cases of comparatively small stations (*see* Table 1, load 2,000 to 4,000 kw., load factor 30 per cent.), where it would certainly not pay to take a bulk supply. In the majority of cases, however, it would appear that a bulk supply would be of considerable advantage. It must not be forgotten that the curve

* Manchester (Barton) Scheme, which allowed for a complete installation of 160,000 kw. of plant, was estimated by Mr. Pearce, City Electrical Engineer, Manchester, to cost £1,775,000, or £11·09 per kw. installed. (*See* p. 532, *Electrical Times*, December 10th, 1914.)


VIN GENERATED
LANT INSTALLED).
£1,000,000.
00,000.
ON BASIS OF
FOLLOWS:-
NNING CHARGES
% ·12
% ·005
% ·005
% ·015
·145
SAY ·150
PENCE.
STATION
PENCE PER KELVIN GENERATED.
TOTAL COST OF PRODUCTION AT SWITCHBOARD.
TOTAL RUNNING COSTS = ·15 PENCE.
75 PER CENT LOAD FACTOR.

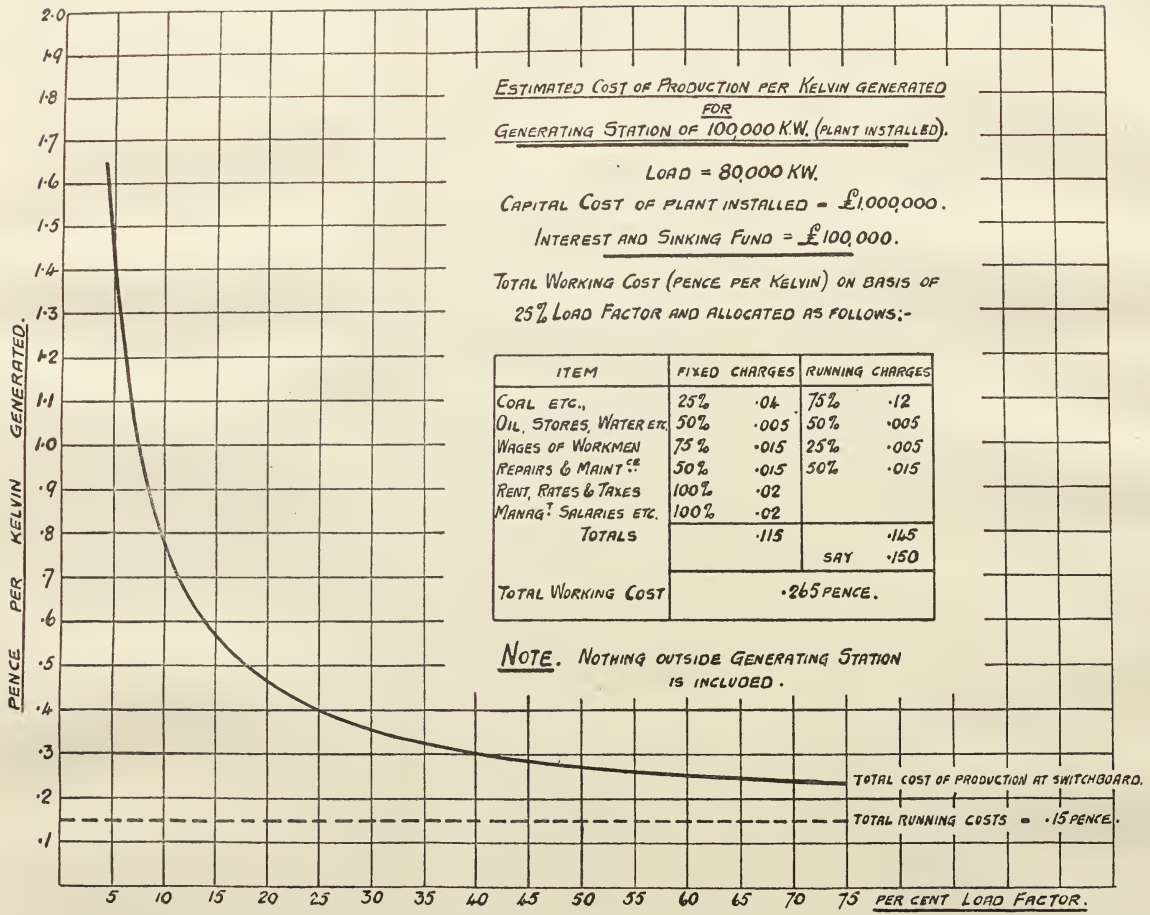

ESTIMATED COST OF PRODUCTION PER KELVIN GENERATED
FOR
GENERATING STATION OF 100,000 K.W. (PLANT INSTALLED).
LOAD = 80,000 KW.
CAPITAL COST OF PLANT INSTALLED = £1,000,000.
INTEREST AND SINKING FUND = £100,000.
TOTAL WORKING COST (PENCE PER KELVIN) ON BASIS OF 25% LOAD FACTOR AND ALLOCATED AS FOLLOWS:-
ITEM | FIXED CHARGES | | RUNNING CHARGES | |
COAL ETC., | 25% | ·04 | 75% | ·12
OIL, STORES, WATER ETC. | 50% | ·005 | 50% | ·005
WAGES OF WORKMEN | 75% | ·015 | 25% | ·005
REPAIRS & MAINT.CE | 50% | ·015 | 50% | ·015
RENT, RATES & TAXES | 100% | ·02 | |
MANAG.T SALARIES ETC. | 100% | ·02 | |
TOTALS | | ·115 | | ·145
| | | SAY | ·150
TOTAL WORKING COST | ·265 PENCE.
NOTE. NOTHING OUTSIDE GENERATING STATION IS INCLUDED.
PENCE PER KELVIN GENERATED.
2·0 1·9 1·8 1·7 1·6 1·5 1·4 1·3 1·2 1·1 1·0 ·9 ·8 ·7 ·6 ·5 ·4 ·3 ·2 ·1
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 PER CENT LOAD FACTOR.
TOTAL COST OF PRODUCTION AT SWITCHBOARD.
TOTAL RUNNING COSTS = ·15 PENCE.

FIGURE Nº 7.

above referred to represents the case of a station laid out with the most modern plant, fully loaded and unsaddled with capital charges on old plant or any other disadvantages under which all the largest Undertakings are working at the present time. In other words the curve represents an ideal state of things which can only be arrived at providing all, or at any rate most, of the existing Undertakings agree to sink their individuality in that of the larger scheme.

Transmission.

This paper would not be complete without some reference (necessarily brief) to the transmission of electrical energy to the various points of distribution which in the case of a bulk supply system would be situated some considerable distance from the generating station.

Many papers have been written on this subject and anyone desirous of studying it more closely should refer to Mr. B. Welbourn's paper* on "British Practice in the Construction of High Tension Overhead Transmission Lines," where reference is made to numerous other excellent papers dealing with almost every phase of this important subject. There does not appear to be any serious difficulty in the way of a bulk supply scheme from the point of view of transmission, except as regards the capital cost which in the case of a large system, such as is referred to in this paper, might very nearly equal the capital cost of the generating station, it being extremely doubtful whether full advantage could be taken of overhead transmission lines owing to the nature of the districts surrounding the great towns in which the bulk supply stations would be situated.

It is also doubtful whether any responsible public electric supply Engineer would care to run the risk of being entirely dependent on overhead lines for his supply because there

* *Journal I.E.E.*, Vol. 52, p. 177, 1914. *See also* Mr. Beard's Paper, on the "Design of High Pressure Distribution Systems," *Journal I.E.E.*, Vol. 54, p. 125, 1916.

is no doubt whatever that the reliability of the supply is, or should be, the very first consideration. Anyone (in this country, at any rate) who depends on such a system of supply runs a very great and grave risk because the climate cannot be depended upon and a violent gale or snowstorm, such as was recently experienced in the Midlands and in the South of England, might very easily result in a total stoppage of the supply. It would be advisable, therefore, that any hypothetical estimate of the cost of the transmission system should be based on underground cables or, at any rate, on a combination of underground and overhead mains carefully interconnected and led to the point of distribution along different routes.

Underground cables for three-phase working up to 20,000 volts appear to present no difficulties whatever and there is no doubt that pressures of 40,000 and even 50,000 volts will very soon become quite common. Such pressures as these will help to eliminate a very large proportion of the cost of the transmission system. It is only by making use of high pressure that the disadvantages of supplying current in bulk over long distances can be overcome.

The disadvantage of the adoption of such high pressures as the above is that step-up, as well as step-down, transformers would have to be used with the result that the transformer losses alone would amount to a considerable sum per annum. That this is not an item which can be neglected is appreciated on referring to the discussion on Mr. P. V. Hunter's paper* on " Static Sub-Station Design," in which it was pointed out that " on the Tyneside Power Company's system the transformer core losses alone amount, owing to the large amount of reserve static plant, to not less than 10,000,000 units per annum."

In addition to the above losses it is necessary to allow for the losses in the cables, due to capacity currents and dielectric losses (which are independent of the load), and also

* *Journal I.E.E.*, Vol. 46, p. 481, 1911.

the losses due to the load which is variable, not to mention the heavy losses which will undoubtedly be incurred in cases where it is necessary to convert the three-phase energy to direct current or alternating current at a different periodicity to that of the bulk supply system.

The author is of opinion that by the time all these things have been taken into account it will be a very difficult thing to prove that an isolated bulk supply Authority is in a position to generate and distribute electrical energy at a price which will allow of a reasonable profit, not only for the supplier but for the distributer, although the case might be altered materially by the linking up of other large undertakings in which case the capital cost per kilowatt (load) could be substantially reduced.

Conclusion.

Although the scheme outlined by Mr. Chattock, and referred to in the introduction of this paper, appears to be surrounded by obstacles, it is nevertheless desirous that steps should be taken to thoroughly investigate the whole question of electricity supply in this country (which is undoubtedly in a state of chaos at the present time) because every day increases the obstacles and delays the time which every Electric Supply Engineer looks forward to and hopes for—the day when electricity will be used universally for lighting, heating, cooking, power and numerous other purposes.

There is not the slightest doubt that one of the obstacles to be surmounted is the jealousy which in many cases exists between one Authority and another, and which is probably greater than that which is generally supposed to exist between nearly all privately and publicly controlled undertakings.

There are cases where such jealousy appears to have been overcome and the author hopes that those who have experience of such cases will come forward and give the Association the benefit of their experience. It has been found to be impossible, under the present circumstances, for the author to enquire into such details, any one of which alone would form the subject of a separate paper.

It would appear that the first thing to be done would be to appoint a committee consisting of members of the I.M.E.A., such committee to be representative of not only the larger Undertakings but of the medium and smaller Undertakings. This committee should have power to co-opt members of other scientific societies, such as the Institution of Electrical Engineers, the Institute of Chemistry of Great Britain and Ireland, etc.

The duties of such committee would be to make a thorough investigation into the whole subject of electricity supply, with a view :

(*a*) To standardise as far as possible the generation and distribution of electricity throughout the whole country.

(*b*) To conserve the supply of fuel used in electricity works and to make a thorough investigation of the important question of extracting from the coal valuable by-products, such as nitrogen, tar, oils, etc.

(*c*) To make use of waste heat wherever possible.

(*d*) To cut down the percentage of spare plant by judicious linking up of adjacent networks. (There are numerous instances where this could be done right away.)

(*e*) To promote legislation whereby facilities may be obtained such as are absolutely essential to the scheme and such as do not exist to-day.

Much that the author had intended to say on this subject when he commenced to write this paper has been anticipated in Mr. Ernest T. Williams' paper* on "The Electricity Supply of Great Britain."

* Read before the I.E.E., March 15th, 1916.

Appendix I.

Type of Plant.	Date Installed.	Capacity in Kw.	Lbs. per Kelvin full load.
Reciprocating engines - - -	1891	80	25·0
,, ,, - - -	1896	130	26·6
,, ,, - - -	1899	500	23·1
,, ,, - - -	1903	450	19·5
Turbo D.C. - - - - -	1906	1,000	17·0
,, alternator - - - -	1909	2,200	16·15
Ljungström alternator (actual) - -	1914	1,000	12·75*
,, ,, (guaranteed) -	1914	1,000	14·00
,, ,, (guaranteed) -	—	5,000	11·8

This table was prepared by Mr. Sidney Baynes of the St. Pancras Electric Supply Undertaking and appeared in the *Electrical Times*, Vol. 46, 1914, p. 399.

* *See* p. 20.

DISCUSSION.

Mr. J. A. Robertson (Member) (Chief Electrical Engineer, Salford) after thanking Mr. Ellis for bringing forward a paper on such an important subject, said that the question of the small or medium-sized station versus large stations was one that required a great deal of investigation. It could not be decided by taking records of works costs as they appeared in the *Electrical Times* or "Garcke's Manual." One of the chief items in these tables of costs was rent, rates and taxes, which Mr. Ellis showed varied by as much as 600 per cent., and moreover it was an item over which the Engineer had no control whatever. The same remark applied to management charges. He would, however, only deal with one or two main points. Taking first Mr. Ellis's Figure 4 it would be seen that there was a drop in steam consumption of from 96 to 86 from the 1,000 kw. turbine to the 2,000 kw. turbine; then there was a straight line from the 2,000 kw. to 5,000 kw.; then a drop for the 6,000 kw. and a straight line again up to 10,000 kw. He did not know where Mr. Ellis had got his information from, because he had figures from a very well-known firm of manufacturers which were perhaps worth noting. For a 1,000 kw. turbine at 3,000 r.p.m. and steam at 550 degrees superheat, and a vacuum of 28 inches, the consumption was 14·8 lbs.; for a 2,000 kw. size it was 14·7 lbs.; for a 3,000 kw. it was 13·2 lbs.; and for a 5,000 kw. it was 12·7 lbs. All were running at 3,000 r.p.m. and were in actual use. There was a difference of 15 per cent. between the 2,000 and 5,000 kw. size instead of the straight line as shown in Mr. Ellis's curve, and even admitting that 3,000 r.p.m. was a high speed for a 5,000 kw. set, then the 1,500 r.p.m. machine had a consumption of 13·4 or an advantage of 9 per cent. over the 2,000 kw. size. If a station employing 3,000 kw. sets had been brought up to date, if it were efficiently managed, and if its area of supply was fairly compact, then there was nothing in the way of bulk supply that could improve the costs of such a station. There were half a dozen medium sized stations in the Lancashire area that were producing energy, with only moderate load factors, showing figures of cost that were better than any figures yet published for large municipal or company stations. This must be taken into account when talking of super-stations being placed up and down the country to supersede existing systems. It was probable that a number of small stations situated in industrial areas might in the future have to shut down their generating plant in favour of a bulk supply from a larger station in the vicinity; that was some-

thing which was coming whether they liked it or not, and was essential in the interests of national economy and national efficiency. Apart from the question of capital cost, there was very little to choose between a 20,000 kw. or a 25,000 kw. station and anything yet estimated for 100,000 kw. The personal factor played a very large part in the cost of production, but, other conditions being equal, it was known that a station with sets of 5,000 kw. or even 3,000 kw. could come very close to the ideal costs which had been heard about for the super-stations yet to be built. As an instance of the reserve with which the published figures of results need to be taken, he would like to refer to the last in the seventh group of Table I, *i.e.*, the 7,000 to 10,000 kw. for which the total working costs were given as .79d. per unit. He thought he recognised that station, and in the interval between the date of the figures given and the present date, modern turbo sets had displaced older plant and the costs had been reduced by nearly 30 per cent., although coal had gone up by nearly 20 per cent. This incidentally, was an example of what could be done in the modernisation of existing stations. A fourteen-year-old reciprocating engine generator of 750 kw. had been superseded by a 5,000 kw. turbine which had been running day and night and had saved £60 a day in fuel. This generated 80 per cent. of the total output, paying for itself in just a little over a year. Mr. Ellis had outlined a somewhat exhaustive programme for the suggested Committee of the Association to deal with. Personally, he did not have any faith in the Association being able to do what was proposed. In saying this he spoke in no hostile spirit, but it must be remembered that the Association was composed of busy men who could not possibly deal with questions of such magnitude. He would go further and say that it was not a matter for any Central Committee. It was a problem to be dealt with at once. They were short of plant in all the stations in industrial districts and the Treasury, acting through the Local Government Board, had practically vetoed all expenditure on new stations. After the war matters would certainly be not less difficult for some little time, yet they would be face to face with a very large demand for power, and it was this which was the problem at the present moment. The reorganisation of British industries was being inquired into by various bodies and reorganisation all round must take place if we were to maintain or improve our position in the markets of the world as it stood before the war. The supply of electrical energy would play an important part in this reorganisation. A glance at the map would show that

nearly all the undertakings in the industrial districts could to-day, with very little expense, be linked up. A movement to this end had been started in Lancashire, and although a lot had been heard about jealousy between Local Authorities, the Lancashire scheme of linking-up had shown that electrical engineers, at any rate, were free from this, and were ready to co-operate in this movement. This was the direction in which they must work, either by Committees formed by the Association on the lines of the Institution of Electrical Engineers' Local Sections or by Committees appointed by Government, but in whatever way it was tackled the problem must be dealt with from the point of view of each district, and the undertakings in each district must first be linked up before a national scheme is practicable. When this was done it would probably be found that it would be possible to run on a plant load factor of nearly 100 per cent. owing to the less efficient plant standing idle or being used only at times of peak load. Linking-up would mean greater reliability, and this was an essential thing at present, because interruption to supply in some districts just now would be something approaching a national misfortune. The cost of inter-connecting the undertakings in industrial districts would not be great when regard was had to the greater efficiency, the better utilisation of reserve plant, and also to the increased reliability of supply.

Mr. H. W. Littler (West Ham), who mentioned that he had now retired from municipal life, dealt with the problem of linking-up from the point of view of London and its surroundings. He was afraid that municipal jealousies had to a considerable extent prevented a satisfactory development of electric supply in and around London, although, at the same time, the community owed a tremendous debt to the municipalities for the manner in which they had developed the electric supply business owing to the fact that, unlike companies, their first consideration was not profits. The problem of linking-up of existing stations would become very much more pressing having regard to the necessity after the war of looking at this question from the point of view of the interests of the country as a whole. He doubted whether linking-up a medium-sized station to four or five smaller stations in its immediate neighbourhood was going to solve the difficulty on account of the fact that in London, municipalities and companies were operating in practically the same area. Then, again, the question of whether there should be a municipal or publicly-owned bulk supply had been raised in schemes proposed

by companies and by the L.C.C., and he was not prepared to say definitely which was the right course to follow in this respect. As he had already mentioned, from the Company point of view, the first thing looked for was profits. Companies did not care if they restricted the output so long as they got big dividends, and in order to secure these they would not launch out into what must be to some extent the speculative work of developing the electric supply on a big scale. Then, in a municipal scheme, although this one element might be got rid of, there was not obtained from top to bottom of the staff of a municipal undertaking that same return per man or per shilling of wages paid which was obtained under Company control. What was required was a scheme which would give the great commercial driving force of the Company with the broadened outlook of the municipality which saw only what was good for the country irrespective of whether it produced dividends or not.

Mr. Ernest T. Williams, referring to the following paragraph in the paper, namely, " in other words, the curve (Fig. 7) represents an ideal state of things which can only be arrived at providing all, or at any rate, most of the existing undertakings agree to sink their individuality in that of the larger scheme," said that if we could develop that attitude of mind a satisfactory future could be looked to. He was delighted to see the steps that were being taken towards linking up, and the progress made in this direction during the past few months had been marvellous, and for this great credit was due to electric supply engineers in various parts of the country. If by linking-up small stations, however, they were going to lose the bigger scheme it would be a great pity. If linking-up meant perpetuating a great many small stations which ought to be wiped out, then linking-up must be very carefully dealt with. Much as he admired Mr. Robertson's very strong advocacy of linking-up certain areas, he could not agree with him in limiting first steps in reorganisation to this part only of the whole scheme. Electrical engineers should take a bigger outlook altogether, and see what was best for the *whole* country. The problem must be looked at from the future as well as the immediate requirements of the country. For instance, the agricultural question dealt with in the next paper was a most important one, and if they stopped at local committees and local schemes they would not attain that greater and more complete solution of the problem which was essential. It might be asked why things should be done which could not be justified financially. This, however, was

a matter which was always coming in front of business men in the ordinary way of business. As an instance, he took the case of a man with £10,000 a year, who by extending his business realised that this income would be reduced for a time to £7,000, but looking ahead he could see a time when the expenditure involved would increase his business and give him £20,000 a year income, and that was the attitude which should be taken up towards the electric supply question. In the past it had been necessary to consider very seriously every item of expenditure, but the industry had now reached a stage where a broader outlook must be taken if the best for the country was to be done. Therefore, whilst there should be every encouragement for schemes such as Mr. Ellis had put forward, and the splendid work of Mr. Robertson in Lancashire and Cheshire, not to mention those who had started linking-up schemes in London, he earnestly pleaded that they should not be short-sighted or narrow-minded in the matter, and that whilst going carefully along they should not continue to extend electricity supply as company supply, municipal supply or anything else in local areas, but that there should be a united effort to work out that larger scheme which had been so much talked of.

Mr. J. W. Meares (Electrical Adviser to the Government of India) said the author's analysis of the working costs from the *Electrical Times* tables agreed very fairly with a similar table printed in his book " Electrical Engineering Practice," recently published in India, and shortly due in a third edition from Messrs. Spon's house. Owing to the existence of a large fan load, much of it operative throughout the greater part of the year, and for, perhaps, eighteen hours a day, they got good load factors, and some of their costs were creditable. It had been a truism that electric lighting was the least profitable part of an undertaking, and yet in England they still had to work under enactments framed for lighting, and patched up from time to time to meet modern needs. The difficulties with which they were confronted rose mainly from vested interests, and in that respect they were more fortunate in India. They began about twenty years ago with a clean slate, and though a great deal of their legislation was modelled on ours they have profited by our example. Thus in the vital matters of *area of supply* their undertakings were able, with very little trouble and no expense, to extend their boundaries as they required. Their rules, corresponding to the Board of Trade regulations, were revised frequently in consultation with the

parties who had to comply with them. Even their Indian Electricity Act, for which he was technically responsible in 1903, was repealed and re-enacted after seven years' experience had shown its weak points. It was found that capital was shy of the compulsory purchase clauses, so a longer term and a bonus on the valuation was introduced in the case of companies. He had always held and freely expressed the view that rules dealing with technical matters should be both drafted and enforced on the broadest lines, since it was obviously not to the interest of an undertaker or contractor to do anything which would cause accidents. It simply was not business to have a fire caused by "the fusing of the electric wire." Nor was it business to cause a death from electric shock. At the same time, it was inevitable that such things must occur occasionally. Judging by results the inspection and regulation of orange and banana skins was far more necessary than that of great industries, for the small culprit stood to lose neither cash nor credit when an accident occurred. For his part, if he found good work done that was not in accordance with a rule, he took the first opportunity of amending the rule as a guide to others. Where technical men were scarce, and unskilled labour was the order of the day, managers were very glad to have clear guidance as to what was good practice. As regarded overhead power lines, he put up the first in India, at Darjeeling in 1896, and when it fell to his lot to revise the rules dealing with them he knew what was practical. For instance, it was clear that a factor of safety of twelve with a 50 lb. wind pressure could not be achieved in supports. At the same time, in a land of storms they must have lines that would hold up, as power lines held in England a few months ago. One would like to know what factor of safety the telegraph lines in the Midlands had, but, of course, they were in a different category. He believed they were interested in wayleaves, and in this matter those in India were ahead of them. A transmission line may pass over hundreds of plots of ground in India, as also may telegraph lines. Under the Indian Telegraph Act the Government could run its lines practically anywhere under simple provisions as to the right of user, and without acquisition. These provisions could now, with the sanction of Government, be made to apply to undertakers. The trouble, however, was that, however well-intentioned a Government technical officer may be, he was not able to do more than advise from the technical point of view; and that was by no means the only point of view.

Mr. C. H. Wordingham (Past President), said a good deal had been heard about "super" supplies and the establishment of enormous stations. He was not sure whether it was to be one or two for the whole of the country, but he ventured to think that the more practical idea was that of linking-up existing stations. Whatever was done, it was necessary to face a very important general question to begin with, for there was no question whatever that everybody would welcome a cheap universal supply of electrical energy in unrestricted quantities for the whole country. That obviously would be a boon to everybody, but the question was whether that supply was to pay or was not to pay. In other words, was the individual who used the electrical energy to pay wholly for his own business, or was the community at large to pay for a portion of it. That was a very wide question, and one by no means electrical, because it took us at once into the region of politics, properly so-called. It really was the question of individualism versus socialism. Were they justified in asking the whole of the community to subsidise them in such a scheme? He did not think it was the English point of view. The English way of tackling a problem was an independent and honourable one, and it was not either independent or honourable to ask the community to make good the defects of the industry. It involved a serious question, because if they asked the community to subsidise the electrical industry, on what grounds could they resist similar requests from the gas industry or the railways or canals, and there was a danger of finding themselves landed in a morass of rank socialism, which he believed very few amongst electrical engineers would regard as an ideal state of affairs. The author had put his finger on the chief point in the problem to be solved, namely, that the industry was not starting with a clean slate. There was already invested in the industry an enormous amount of capital, and although it was all very well to run down the small, inefficient, and inadequate stations, after all, if it had not been for these stations, and for the enterprise of those who put them up, there would have been no electricity supply business whatever at the present time. What was to be done was not to invent ideal conditions to suit the solution they wanted to put forward, but to find the solution to meet the conditions which actually in fact existed to-day. From this point of view Mr. Robertson's remarks as to linking-up were very sound. The problem could not be attacked on hard and fast general lines, but all cases must be considered on their merits, and each district must work out its own salvation. When each district had

got a system of linking-up then it was time to think about linking-up one system to another, and not before. There remained the question of Government interference with the business, and he could not help feeling that it would be an advantage to have the present Government control which was scattered over several departments concentrated in one Government Department composed of capable engineers, and not of clerks and lawyers, which could lay down certain rules to be conformed to as to the expenditure of any additional capital on the electric supply business. That would be perfectly reasonable, just, and helpful. So long as the Government confined itself to regulating the supply, laying down conditions, and did not in any way trade or attempt to have any finger in the supply of electricity, then it could be helpful. He did not propose to criticise the paper in detail. He held very strongly that there was nothing so deceptive as figures, and he believed the tables published in the *Electrical Times* had been responsible for more false deductions than almost anything else in the industry. Everybody must admit that there were advantages in a large station, advantages that were gained by serving a large area, and, therefore, getting better diversity; in some cases there was a better load factor, and in others it was worse, and there were undoubted advantages in being able to use large plant instead of small.

Mr. S. J. Watson (Member) (Chief Electrical Engineer, Bury) said that although a good deal could be said for the argument that small power stations by developing along the lines of large units might become quite economical, a good deal could be said from the other point of view. It depended not only on the ability to provide larger sized plant in substitution for existing plant, but also on the suitability of the site for the economical operation of that plant, the water facilities, and also for the ease with which it obtained and used its supplies of fuel. A good deal of the discussion, in his opinion, had had very little to do with the paper, but as so many speakers had discussed the question of linking-up, perhaps they would excuse him adding a few further comments. The difficulties in the London area had been dealt with by Mr. Littler, and in connection with the question of company supply and municipal supply it must be remembered that whereas municipalities had their powers in perpetuity, the companies had only a limited tenure, and this had its effect upon the commercial development. An instance in the opposite direction was to be seen in the Lancashire and the Yorkshire power companies, who,

by reason of having their powers in perpetuity, had made splendid progress for a large number of years. Some speakers seemed to think that linking-up was the beginning and end of the work which electrical engineers had in view. Linking-up would tend to develop existing resources to a better extent than had previously been possible but, in his opinion, this was only one step in the direction of carrying out the larger scheme, and by that he had in mind that if linking-up was developed, certain boards or committees would be set up with such powers that they could say whether undertakings should be extended, or whether, owing to the less suitable site, for instance, undertakings should take their supply from a larger undertaking outside the district. Indeed, a complete scheme went further than that, because as districts linked up and power stations increased in size, these districts would in the future connect with other districts, and so as time went on he hoped there would be a system whereby power might be interchanged between all the districts of the country. If every one worked together, and put aside local jealousy, there should be a tremendous development in the electric supply industry which would result in a reduction in costs and, consequently, a reduction in the selling price.

Mr. W. B. Woodhouse (Yorkshire Electric Power Company) said his views on linking-up were very well known. He felt that the only real line of development was the process of linking-up existing organisations and using them to the utmost extent, in order to lead up to the national supply system that was aimed at. The local experience already gained of local conditions would be utterly wasted if they started at the other end, and created a municipal or State electricity board who knew nothing whatever about the local conditions. They had seen in the North the misfortune of trying to work undertakings from London ; whereas in other cases where undertakings had been worked by local men they had gone ahead. The Incorporated Municipal Electrical Association had done a splendid work in discussing the matter, and speaking as a representative of a power company, the power companies of the country appreciated the broadminded way in which the subject had been discussed by them. If electrical engineers were left to themselves for a little while he believed they would find a solution.

Mr. J. H. Bowden (Member) (Chief Electrical Engineer, Poplar) said a great deal had been heard about linking-up, but very little about bulk supply ; but in his opinion there was a very

wide difference between bulk supply and the advantages to be obtained from linking-up. Some of the engineers in London had advocated linking-up for eight or nine years. The Poplar station had been linked-up with Stepney for six years. It was now linked-up with Hackney, and negotiations were in progress for linking-up with the South Metropolitan Company and also with West Ham. Advantages could be claimed under three heads: firstly, standardisation of supply; secondly, reciprocal supply; and, thirdly, bulk supply. Long ago he decided that, as far as Poplar was concerned, bulk supply would be practically valueless. As was known, there was now an arrangement with Stepney that neither should spend capital on new plant until one station or the other had reached a certain capacity, and utilised all the plant which had been installed. He had looked for a definite expression of opinion in the paper advocating either that small stations should generate their own supply, or else that they should take a bulk supply, but there did not appear to be any definite recommendation one way or the other. It might be argued as regards linking-up that the capital expenditure would not be compensated by the advantages which he had claimed unless some definite bulk supply was taken, but he was strongly of opinion that the advantages gained in reciprocal supply by shutting down during the night, and light loads and the joint facilities for overhauling amply repaid the expenditure. Reference was made in the paper to a coal clause. Personally, he had always objected to this, but he agreed with the author that it was a necessary evil. At the same time, the difficulty as far as linking-up and bulk supply was concerned could be obviated to a very large extent by not having a coal clause as they were generally worded at the present time, but a coal clause similar to that arranged between him and the stations with which he was linked, something to the effect that in the event of the supplying authority shewing that the cost of fuel per unit generated in any quarter was more than Xd. per unit generated, the charge should be increased so as to equal the extra coal cost per unit generated during the quarter. That was fair and better than having a percentage increase per unit for the increase in the cost of coal. The author mentioned that the lower total costs obtained were largely due to the effect of improved load factor on the other items which make up the total work costs. He did not altogether agree, because the increase in output had a very much greater effect on the total costs, but the load factor generally affected the coal figures. There was also a reference to the proximity of

generating stations to a coal mine, which enabled small coal to be bought for almost a nominal sum, but this was rather contradicted by the author's statement that although he was situated close to a coal mine he was unable to obtain it because it was dumped into boats. He would like to know a station where coal could be bought for almost a nominal sum as the author had said.

The author refers to Poplar and Stepney costs. He, however, states that the record is held by Poplar and Stepney. It is difficult to understand how two undertakings with different costs can both hold the record, but a reference to the fact that the two undertakings having the lowest costs in the Metropolitan area were the first to link-up would have had some significance.

In dealing with the working costs of these undertakings the author might have noticed the fact that, although there was a difference of .09d. in the coal cost, the total difference was only .07d., which was entirely due to the extremely heavy rates in Poplar, which is, of course, outside the control of the Electricity Department.

The author refers to the purchase of coal by large undertakings, and infers that an advantage accrues therefrom, but this is not so in actual experience, as it is essential to cover by contract to a great extent when large quantities of coal are required, whereas the smaller undertakings can take advantage to a very large extent of " spot lots " of coal, which, in normal times, are always procurable. He also makes the statement that the difference in efficiency between large and small turbines is slowly but surely diminishing, and appears to consider a difference of 2.2 lbs. of steam per unit inconsiderable. It may be worth while to mention that with a 25 million output, and coal at 25s. per ton, this difference amounts fo £3,750, no small matter in these days when loss is more usual than profit.

The author and some of the previous speakers referred to jealousy between undertakings, but when stations are linked-up similarly to Poplar, Stepney, Shoreditch and Hackney, that jealousy is, in a great degree, eliminated.

Councillor Sinclair (Swansea), speaking on the question of the advantages of bulk supply, mentioned an agreement recently entered into between the Swansea Corporation and the Swansea

Tramway Company, which he said was to the mutual benefit of both parties. It was essential that linking-up should be developed to its utmost extent in order to prevent the erection of plant on manufacturers' own premises, plants which had been very efficiently run, and he knew in many cases of costs which would put many public electric supply stations to shame. Having succeeded in making the agreement with the Tramway Company, he was now preparing to tackle bigger things, but he knew he would meet with jealousies from certain authorities concerned, and those jealousies, he was sorry to say, would be far greater than the jealousies of companies. Personally, he thought there was plenty of room for both electric supply companies and municipalities, and linking-up schemes must be developed between both forms of supply. It must not be approached from the point of view of a company shutting down and taking supply from a municipality, or a municipality shutting down and taking supply from a company. The whole problem must be viewed from the national point of view, and what was best for the community should happen.

Mr. A. H. Shaw (Ilford) (Member) (*communicated*) : As representing one of the smaller stations, Mr. Shaw is much interested in the questions dealt with in the paper and regrets that the time allowed for discussion did not permit the members representing such stations to state their views.

The author states " the best way to improve the load factor is to increase the number of industries connected." In many undertakings in which the possible power load is limited, the only means of obtaining this result is by pushing the heating and cooking business. Mr. Shaw's experience, however, is that it is impossible to do much in this way, unless the necessary apparatus can be let out on hire. It is useless leaving this business in the hands of contractors and he trusts the Council will proceed with the I.M.E.A. Bill and obtain these indispensable powers for the smaller undertakings at the earliest possible moment.

The figures given of possible steam consumptions of reciprocating engines appear to Mr. Shaw to be too low. They are lower than he found any manufacturer willing to guarantee, and even if they could be obtained on test he considers in ordinary working the actual consumption would be considerably higher. It would be interesting to know what the actual consumption of the author's engines is, if he is still running them.

Mr. Shaw agrees with the author that in certain cases where a station has ample water facilities and is favourably situated with regard to coal supplies and the handling of same, it may be more economical to extend such stations with modern turbines rather than to take a supply in bulk from an external source.

Unfortunately, many small stations were planted in unsuitable positions some fifteen to twenty years ago, and in some cases these stations are in adjacent districts only a few miles apart. Where no external bulk supply is available a solution may perhaps be found by the neighbouring authorities appointing a joint board and erecting a bulk supply station in a suitable situation to supply themselves. Such a station would then supply the main load of each of the smaller stations, these being chiefly used as converting and distributing stations and possibly assisting the bulk supply on the peak. By such means the load factor of the bulk station would probably reach 70 to 80 per cent. and the costs of supply would be reduced to a lower figure than it would be possible to attain at some future date by taking a bulk supply from some large company with high transmission costs.

Mr. Shaw has had a case in mind for some time past in which three D.C. stations, all erected about fifteen years ago, are supplying adjacent districts. There are no adequate water facilities at either of them and all coal has to be carted from the nearest railway sidings. They are all within a radius of 1½ miles, two of them being less than 1½ miles apart. Within about 1 mile of these two stations a suitable site could be found with ample water facilities for condensing and coal delivery and a railway siding could be arranged. Unfortunately, the narrow views of certain parties referred to in the paper stand in the way and it is very hard to get neighbouring authorities to agree upon any such joint action.

Mr. Shaw is strongly of the author's opinion that some Committee should be appointed to deal with this matter at an early date, though he does not consider the I.M.E.A. should appoint such a Committee, as they would have no power to enforce their recommendations. He is of the opinion that the Government should take this matter up and that they should compel local authorities to carry out the suggestions of any such Committee, prohibiting the further extension of small stations where they

deem it advisable to do so. By such action a considerable saving in coal would be effected, which in the case of many small stations would probably amount to from 40 to 50 per cent. of the present coal per unit.

Mr. H. S. Ellis, in his reply (*communicated*), says, in reply to Mr. Robertson, he would like to make it clear that there was no intention on his part when he prepared Table No. 1, to mislead anybody with regard to the various items which go to make up the figures for the Total Working Costs in the case of various undertakings. Therefore he does not consider it was quite reasonable of Mr. Robertson to compare figures under the heading, " Rents, Rates, and Taxes," which showed so big a difference as 600 per cent. This Table was the result of averaging various costs of large numbers and groups of undertakings for the purpose of arriving at such results as are given in Table No. 3, which shows the relative Works Costs and relative Total Working Costs of various classes of undertakings. This Table is entirely in avour of the larger stations, therefore the author fails to see why Mr. Robertson should take the trouble to pick out one isolated undertaking, which appears at the bottom of Table No. 1, in which case the Total Working Costs are exceptionally high, namely, ·79d., and compare this figure with other figures in the Table, although it is certainly interesting to hear that since modern turbine plant was installed a very considerable saving has been effected in this particular case. This bears out the author's own statements with regard to the saving which can be effected in comparatively small stations where modern turbine plant supersedes more or less obsolete reciprocating plant. The author is interested in the figures which Mr. Robertson gave of the steam consumptions of various turbines, and he is prepared to admit that Fig. No. 4 shows the larger sizes of turbines at a disadvantage, but he has had it confirmed since the meeting that the figures indicated in the curve are by no means incorrect, although the figures for the larger sizes of turbines might be improved upon, providing special features are called for in the specification. But where makers standards are accepted such figures as are indicated in the curve would probably be obtained. It is not a very difficult matter to find fault with the figures which Mr. Robertson gave for the 1,000 and 2,000 kw. sets at 3,000 r.p.m., in which case the steam consumptions were given by him as 14·8 lbs. and 14·7 lbs. per kw.h., respectively. There is about as little difference in these figures as there was in the figures which Mr. Robertson took exception to in the curve

referred to. With these exceptions, Mr. Robertson appears to be generally in agreement with the author, who tried to show in his paper that stations having a maximum load exceeding 2,000 kws. were probably in a position to produce current as cheaply as they would be able to do if a bulk supply was taken. This fact was demonstrated very clearly in Fig. No. 2, which shows the curve turning very rapidly where the load is in the region of from 1,500 to 2,000 kws.

With regard to Mr. Robertson's remarks regarding the programme which the author has outlined in his paper for the Committee of the I.M.E.A. to deal with, he would like to point out that this paper was written before he was quite clear as to what arrangements had been made in Lancashire for dealing with the important question of linking up various undertakings in the Lancashire and Cheshire districts. Had he known all the circumstances of this particular case he should probably have modified his statements somewhat, but he fails to see why the I.M.E.A. should not have appointed a committee such as would have suggested the formation of committees of electrical engineers in various districts for dealing with the question of linking up as has been done in the Lancashire and Cheshire districts. The author is quite prepared to admit that the problem is too big for one central committee to deal with, but there is no doubt that if local committees are formed all over the country such as has been formed in Lancashire and Cheshire, the time will come when a central committee will be formed of delegates from these local committees, to deal with the larger question of linking up one area with another. It would appear, therefore, that the only difference between Mr. Robertson's scheme and the author's is that in Mr. Robertson's case the tail would appear to be wagging the dog.

The author is entirely in agreement with Mr. Williams' remarks, and more especially so where he says that " there should be a united effort to work out that larger scheme which has been so much talked of."

Mr. Meares' remarks with regard to wayleaves in India are particularly interesting, and the author is glad that he agrees with him that the Government should take steps to insure us the right to obtain wayleaves reasonably quickly and on reasonable terms.

Mr. Wordingham's remarks are, as usual, to the point, and the author is glad to note that he has appreciated the real argument in his paper with regard to the smaller undertakings which are already fairly well established. Mr. Wordingham's remark that "the industry is not starting with a clean slate," is very pertinent, and there is no doubt that some people are expecting far too much when they call for the smaller undertakings to immediately scrap their plant and rush to the nearest large undertaking for a bulk supply, at a figure, such as may, when added to the already heavy standing charges on obsolete plant, plus the cost of conversion, result in an adverse balance for many years to come.

With regard to Mr. Watson's remarks, the author is afraid that he is not quite clear as to whether Mr. Watson is in favour of the smaller stations taking a supply in bulk or not. It is rather interesting to note Mr. Watson's remarks on this subject in view of the fact that the station which he controls, although a comparatively small one, and coming in the category of 2,000 to 4,000 kws., shown on Fig. No. 1, produces current at a lower Total Working Costs figure than most of the very largest stations in the country, and the results obtained in the case of Mr. Watson's station indicate what could be done in comparatively small stations, providing modern plant is installed and a good load factor obtained. The only conclusion which the author can come to is that Mr. Watson would class his undertaking amongst the larger undertakings, in which case he would be prepared to supply current to the smaller stations, although perhaps he would not be prepared to take current from some neighbouring station which was very much larger than his own, but where the Works Costs were very much higher.

With regard to Mr. Bowden's remarks, the author thinks he expected too much of the author when he expected him to make a definite statement to the effect that small stations should take their supply from the larger ones in preference to continuing to generate electricity on their own, because it is rather a difficult matter to decide what are small stations at the present time compared with such stations as we have heard about recently. There are probably only a dozen power-stations in this country that could be considered large stations. Therefore, it would be going rather far for the author to suggest that the whole of the small stations should cease to generate and take their supply from the Super Stations. Such a state of things is absolutely

impracticable at the present time, and is likely to remain so until the various networks throughout the country have been linked up and a demand created for several Super Stations capable of an output of from 100,000 to 200,000 kws., or even more. Mr. Bowden's remarks with reference to a coal clause are extremely interesting, and will no doubt be very useful to engineers who are called upon to enter into agreements with large consumers for their electricity supply. Referring to his remarks regarding the author's reference to the proximity of generating-stations to a coal mine, he thinks that Mr. Bowden is bound to agree that it is an advantage in most cases to be close to a coal district, but in the case of South Shields they happen to be situated at the mouth of one of the most important rivers in the country, and consequently the local collieries have no difficulty whatever in getting rid of their coal at high prices, whereas many of the inland collieries are only too glad to have a steady customer such as an electrical undertaking is.

Referring to his remarks regarding the difference in the efficiency of a 1,000 kw. and 5,000 kw. Turbo Set mentioned in the paper as being 2·2 lbs. of steam per kw., the author would like to point out that he did not refer to this figure as being "inconsiderable" nor did he intend to infer that it was. Furthermore, he fails to see why Mr. Bowden should inflate his own agreement by taking the cost of coal at 25s. per ton. Some people may be paying this price owing to the present abnormal conditions which have arisen out of the War and which are, it is to be hoped, only temporary. The author is paying considerably less than half this figure for coal and will continue to do so until the end of 1917.

The author is in entire agreement with Mr. Shaw's remarks when he says that the time allowed for the discussion of the paper did not permit the members representing the smaller stations to state their views. In fact, it is rather discouraging, when one has taken up a considerable amount of valuable time in preparing a paper, to find after the same comes to be read, that there is not even time for the author to reply to the discussion. It is hoped that in future more time will be devoted, when necessary, to this matter.

Referring to Mr. Shaw's remarks regarding steam consumption of reciprocating engines referred to in the paper, the author would like to point out to Mr. Shaw that these figures do not apply to

such reciprocating plant as is at present installed in the author's station (and which is merely used as a standby to the more modern turbine plant), but to modern high-speed reciprocating plant, and the figures given are the figures recently supplied to the author by a well-known firm of manufacturers. The author is very much interested in the concluding paragraph of Mr. Shaw's remarks, because there is no doubt whatever that some sort of Government pressure will have to be applied to many of the smaller undertakings before they will agree to take their supply from an outside source.

The author gathers from the remarks of the various gentlemen who have taken part in the discussion that on the whole they are in agreement with the paper, and there is not the slightest doubt that the proper thing to do in connection with the electrical supply of the country is to link up undertakings with others wherever possible, and then when the time arrives to put down large stations, such as could be worked at a very high load factor and where it would be possible to obtain sufficient load to load the whole station up immediately it was completed.

The idea which seems to have been prevalent recently of immediately building Super Stations, and then for the engineers of such stations to run about the country finding load, will simply result in these stations being a drain on the resources of whoever is responsible for them, because it will mean that before a station is completed and the whole of the available supply in use the first plant installed will be more or less obsolete.

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The Application of Electricity to Agricultural Purposes.

By W T. KERR (*Member*).

City Electrical Engineer, Hereford.

UP to the present time the use of electricity in farming has not attracted the attention that it undoubtedly deserves on the part of the Electric Supply Authorities, Electrical Manufacturers and Engineers in this country.

This is the more surprising in view of the very close attention which has been given to the subject on the Continent of Europe and in America, and the important and extensive schemes for supplying agricultural areas which have been carried out in different countries.

In Germany and France, where the necessity for the scientific development of the agricultural resources of the country has met with far greater appreciation than in this country, official recognition has been given to the utility of numerous agricultural electric supply schemes; while Italy, Austria, Switzerland, Denmark, Holland, etc., all afford practical examples of farm supply on a fairly extensive scale.

But probably the greatest aggregate of agricultural consumers is found in the United States, where it is noteworthy that California—a purely agricultural State—uses more

power per head of population than any other American State. Canada also furnishes an interesting example of farm supply on the Ontario Hydro-Electric Commission's extensive distribution system, and practical examples of a similar kind are to be found in Australia, New Zealand and elsewhere.

It must be quite evident that such widespread attention would not be given to this matter unless considerable unanimity prevailed both as to the value of electricity to the farmer and as to the profitable character of the business of supplying him with electricity.

In placing the following rough notes before you, the author wishes to emphasise the fact that there is awaiting development in this country an enormous business of a similar kind, which will also place at the disposal of the agriculturalist a labour-saving source of power and light superior to any other. The writer's conclusions are based on some years' experience in farm supply work in the neighbourhood of Hereford, where it is quite reasonable to suppose that conditions are not more favourable than in many other parts of the country for this particular class of supply.

The following extract from a technical article on the subject of rural and domestic applications of electricity, gives some idea of the scale on which Continental operations of this kind are carried on :

> " In Germany, Northern Italy, and throughout Switzerland, there is an extended use of electrical energy in agricultural communities.
>
> " A network of distributing lines has been formed, owing to the scattered and numerous sources of hydro-electric power.
>
> " As an example of the extent to which a single rural central station may supply a farming community, the rural station of Besswitz may be cited. The distribution system is 145 miles long, and the central station being as nearly as possible at the centre of the network, the greatest distance of supply from the station is twenty-six miles. The territory served, according to the American *Electrical Review and Western Electrician*, is 102,000 acres in extent, of which 40,000 acres are cultivated with the plough. To this network are connected 180 motors and 5,000 lamps, with a total consumption of 1,300 kw.

"The energy is sold on a sliding scale basis: 3d. per kw.-hr. is charged for lighting purposes, and for power the rate varies from 1¼d. to 2d., depending, of course, on the quantity consumed.

"Many of the German farmers have rural industries connected with their farms, whereby they utilise their by-products, and herein lies the secret of the success of many well-to-do farmers.

"For example, on one of these installations there are connected four grist mills, with five motors aggregating 105 h.p.; one tile works, with a 40 h.p. motor; one saw mill, with a 20 h.p. motor, and so on.

"There are also connected 20 consumers for lighting only, with a total of 343 incandescent lamps and six arc lamps.

"From the above facts and figures, it will be seen that electricity can give a new stimulus to agriculture and farming, and at the same time open up a way by which the rural population can be induced to remain on the farm, instead of flocking to overcrowded cities, and taking up an entirely new form of work to earn a living."

It may be noted that several of the important Continental electrical firms specialise in electrical apparatus for farms; the Oerlikon Co., of Zurich, issues a special catalogue on the subject, showing applications of both alternating and direct current motors, both stationary and portable—the latter mounted upon a handbarrow with a reel of cable for connecting to the supply. Portable motors of fairly large size are also built for driving thrashing machines, etc. Some engineers in the United States have even gone so far as to incorporate the motor in the farm machine, in the same manner as in modern machine-tool work.

In an article in the *Electrical Review* of June 4th, 1915, it is shown that very similar conditions exist in Britain, although it would seem that the average would be greater in this country, both as regards units consumed and horse-power demand, as the farm machinery in general use here is of larger and more substantial types.

Fortunately, we are quite able to compare results from experience of practical supply to agriculture.

The last report of the Ontario Hydro-Electric Commission contained some particulars of farming supply in Ontario, with data as to energy used on farms; the average yearly consumption per farm for all purposes was 4,700 units, and the average revenue £27.

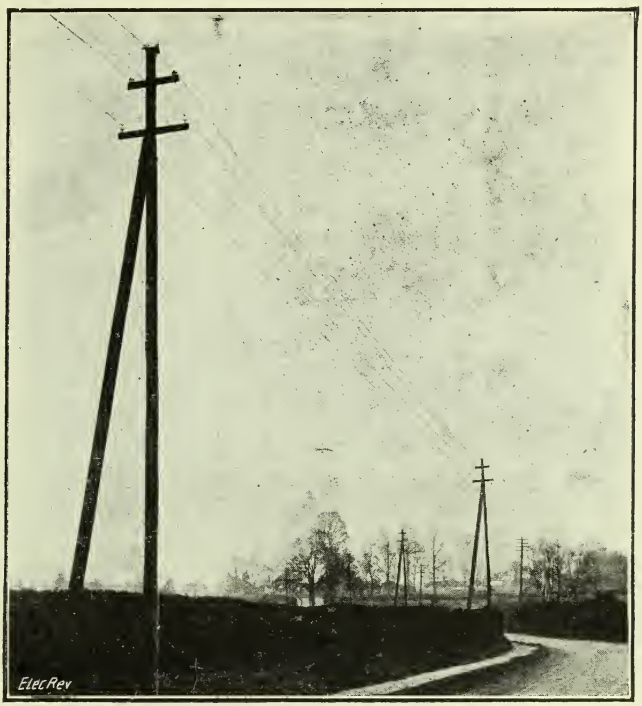


Fig. 1.

Light Transmission Lines.—In the Hereford district a system of light transmission lines has been erected, as shewn in Figs. 1, 2 (*a*), (2*b*), to reach the agricultural consumers. These are built with larch poles, 28 feet long, with cross arms of quarter oak 2 feet 6 inches by 3 inches by 3 inches, the bottom arm 3 feet. The lines are usually now made up to

7/10 B.S. G. bare stranded aluminium, weighing about ·032 lb. to the yard, and costing before the war 1s. 0¼d. per lb., with two No. 12 galvanized guard wires below, which are also used as the neutral, the supply being given at 440 volts, three wire (220 volts for lighting).

The total cost, including labour, works out at £110 per

Fig. 2 (*a*).

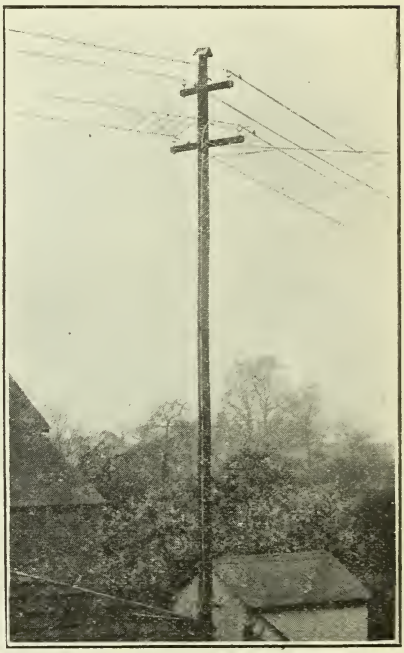


Fig. 2 (*b*).

mile. These lines have withstood the gales of December, 1915, and March, 1916, without a breakdown.

The farthest distance a supply is given in 3,400 yards from the generating station, 1,200 yards of which is by overhead lines; these radiate in five districts from the station to an average distance of 3,000 yards.

When erecting the poles, it has been found better to place them close into the hedges, otherwise the cattle use them for relieving themselves of insect life, to the detriment of the line ; also farmers object to their being placed any distance out in the fields, and the hedges and ditches act as a guard.

Such lines can be arranged with quite long spans, 75 yards

Fig. 3.—Farm Buildings Distribution.

in places, between the poles, to cut across corners, if the route is carefully considered before the erection.

Tappings to consumers are taken off by means of a twin-lead cable clipped to the pole. It is very important to seal both ends of the cable where the leads are taken off, and this is usually done at the top of the pole by securing a small type sealing box to the pole and taking-off

leads, leaving a short bare space on the wire between the lead-covered and rubber-covered leads where the thimble is sweated, and afterwards sealing this with compound.

The connection to the aluminium wire is made by means of a "jim crow" shaped clip, which grips the wire in two positions, the lead being sweated to a screw used for tightening in the centre, and the whole joint afterwards painted over with aluminium paint; no trouble whatever has been experienced with such a joint, although one section has been in constant use for nine years, connecting up a supply to a 50 h.p. motor from an aluminium overhead line running alongside a main line railway.

In an average case, a 10 h.p. motor will meet all the power requirements of a farm, except for thrashing and cider milling, but motors up to 20 h.p. have been hired out for these purposes, which are only seasonable jobs, and do not require a permanent fixing.

Way-leaves.—The greatest obstacle to cheap rural supply is the question of way-leaves; when it is necessary to go outside the boundary of a Provisional Order area to supply in a district without such an order, many unnecessary legal difficulties are encountered.

One experience has been that a line to supply a farm building and residence was held up over twelve months, although it was only necessary to cross two small meadows, certain members of the local District Council viewing the application for permission to supply electric power as a means of negotiating for an extension of water supply to a house quite two miles away.

Application was made to the Board of Trade for an overriding order, and they suggested further negotiations before granting it. When an agreement was eventually come to, the legal costs amounted to more than twice the cost of the transmission lines, and the prospective consumer had been

kept waiting for a period of twelve months, although the installation had been put in, and it was only necessary to cross a field to give the supply.

This, obviously, is not as it should be; such obstacles prevent proper development and are a bar to progress.

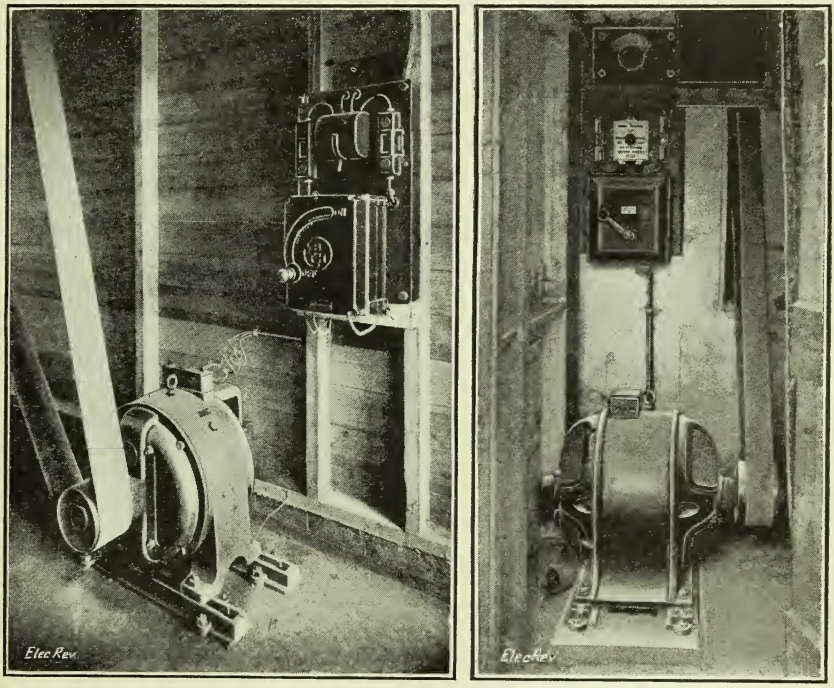


Fig. 4.—Typical Farm Motor Installations.

Farm Installations.—A description of the plant and power uses on a Hereford dairy farm may be of interest.

The installation, shown in Fig. 5, consists of an 8·5 h.p. open type motor, running at a speed of 960 r.p.m., with the starting panel mounted alongside; the small machine

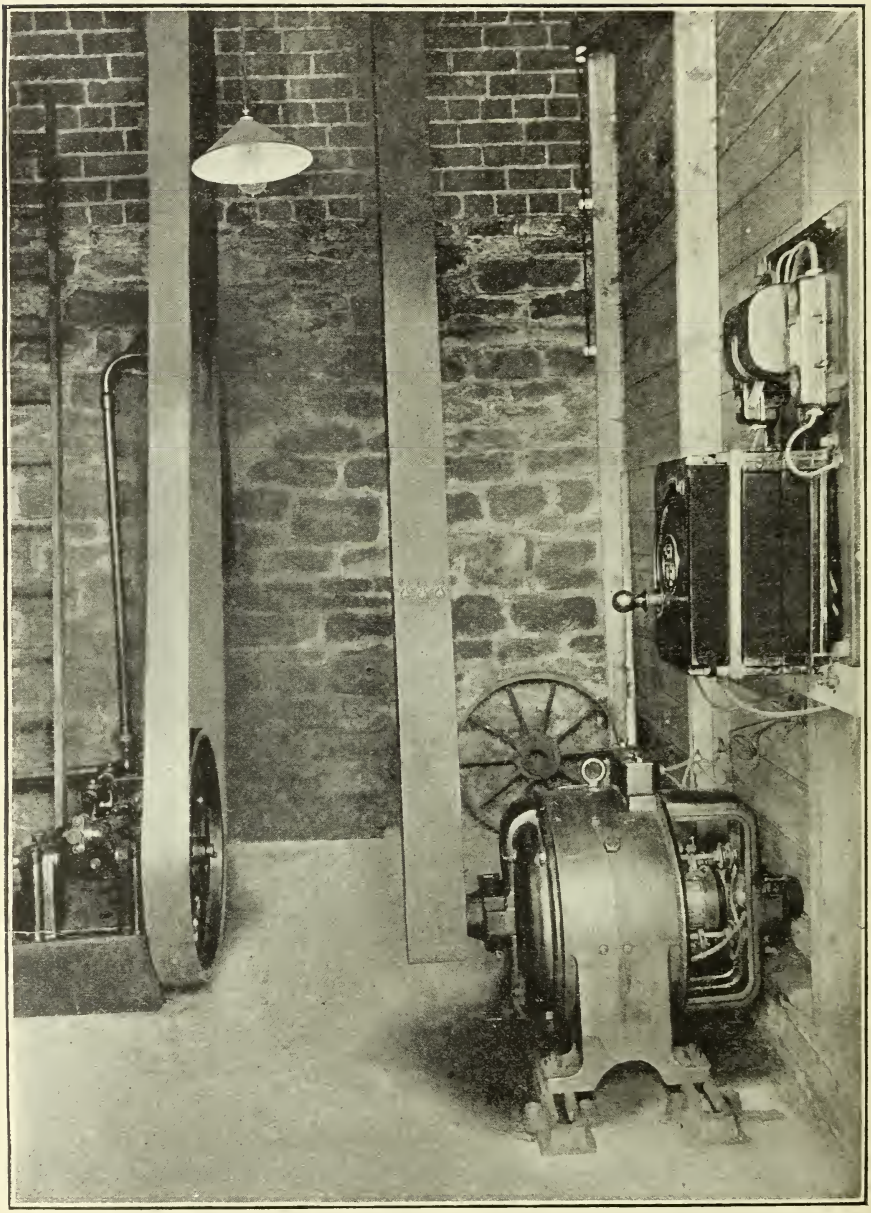


FIG. 5.—MOTOR DRIVING LINE SHAFTING ON A FARM; ALSO AIR PUMP FOR MILKING MACHINE.

on the left is the vacuum pump for the milking machinery, and requires 1½ h.p. This machine is used twice daily, for about two hours in the morning and one and a quarter hours in the afternoon. The cows milked average about seventy, and the machinery has a capacity of eighty-eight.

The farm bailiff states that it would require five men at least, who are expert milkers, to do the work in the same time, or with his present staff five or six hours a day longer.

Fig. 6 shows the cows during milking operations ; Fig. 7 the sterilizing and filtering room, and Fig. 8 the root pulping and chaff-cutting machines on the floor above, the machines being so placed in order to keep out all the dust which generally arises when dry hay is being cut. The roots are thrown over into the machine hopper, and the chaff comes down the shute on the wall, the two are mixed and fed fresh to the cattle. Experience shows that owing to the easy starting of an electric motor the exact quantity of food can be cut and mixed fresh as required, a very important result being a greater yield of cream in the milk.

A machine for kibbling corn and rolling oats is installed, also a circular saw for splitting wood and fencing material.

This represents a typical installation, but there are many other operations that could be done most efficiently by electricity by any farmer enterprising enough.

In the future an apparatus for electrically heating water will be installed. The farm buildings are lighted throughout, there being twenty-five lamps of 25 c.p., and, in addition, the bailiff's house and some cottages are supplied off the same line through " Penny-in-the-Slot " meters.

The units consumed on this farm for year ending 1915 amounted to 2,411, at 2½d. per unit, and the revenue reached

FIG. 6.—100 COWS BEING MILKED ON A FARM. 1 H.P. TAKES PLACE OF FIVE MEN.

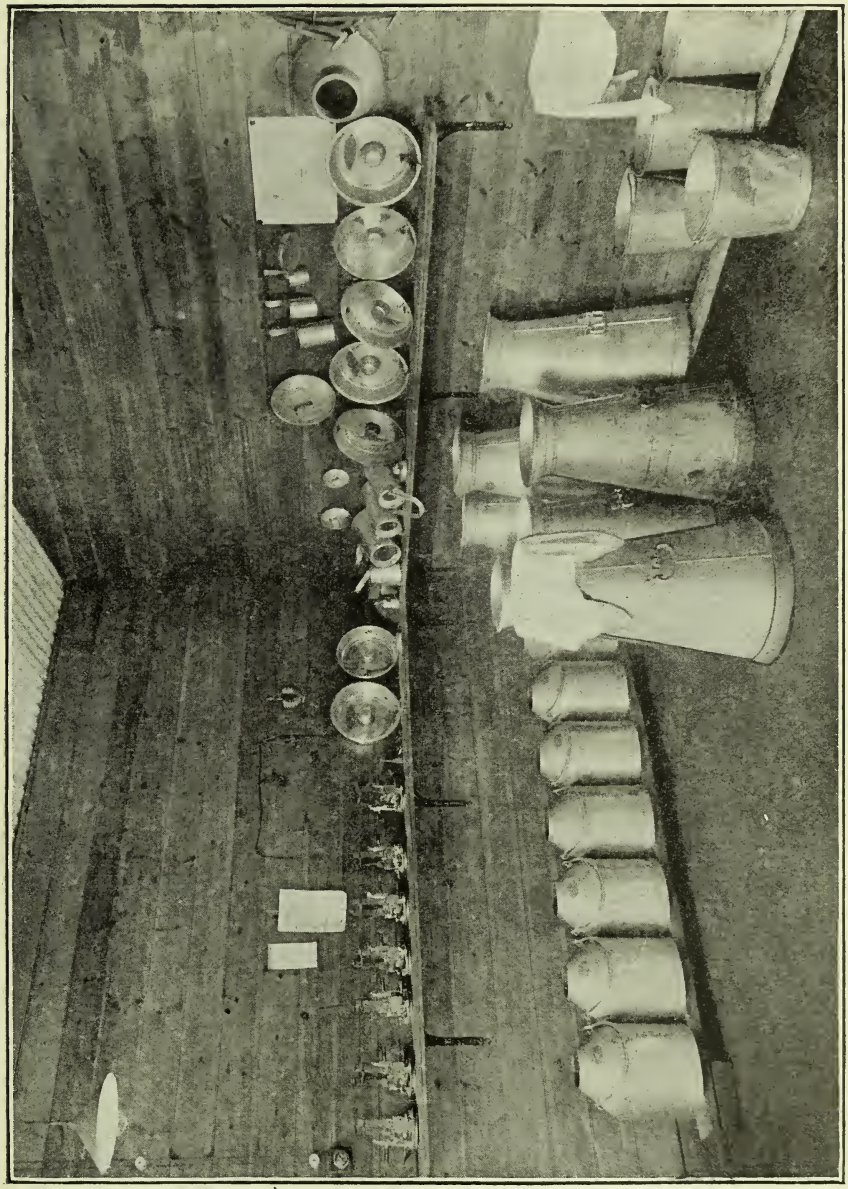


FIG. 7.—CORNER OF THE DAIRY SHOWING MECHANICAL APPLIANCES STERILIZED AFTER USE.

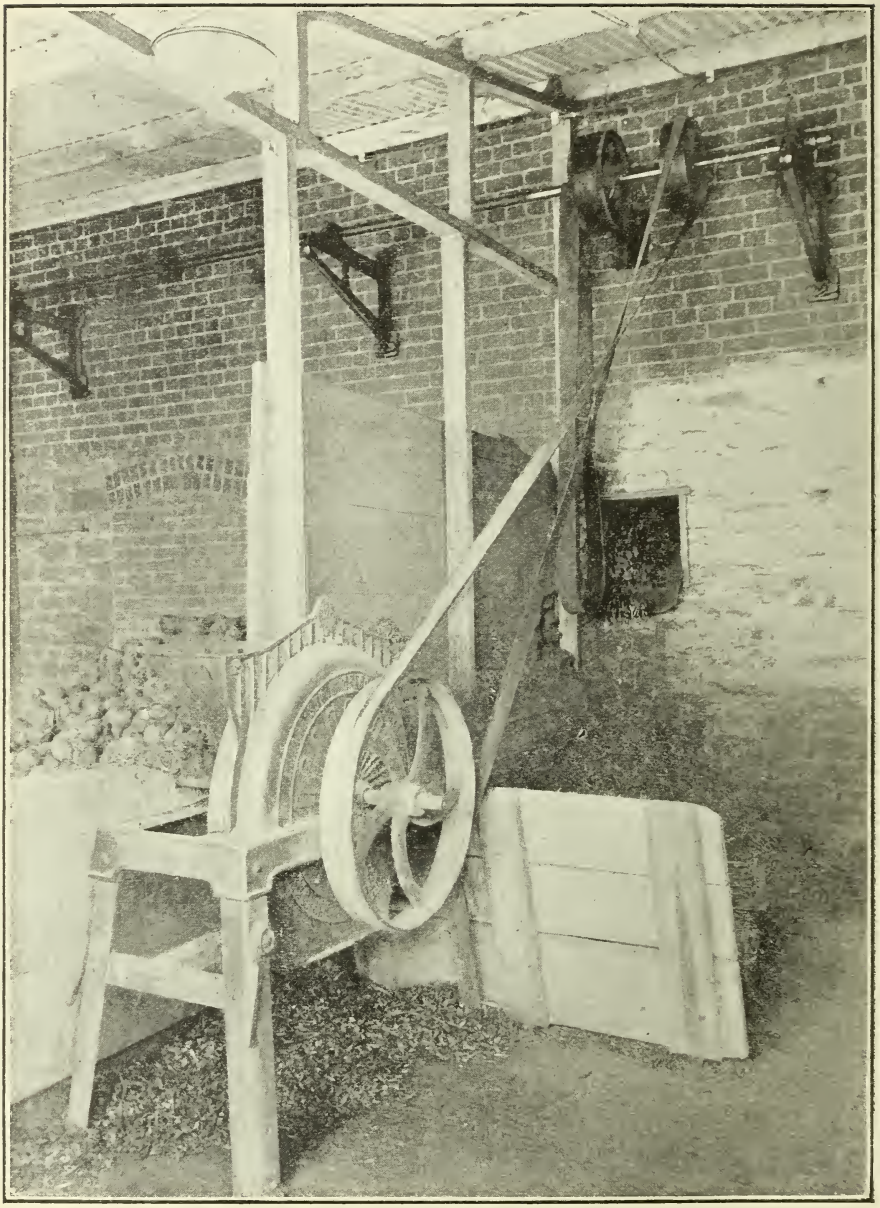


FIG. 8.—ROOT AND CHAFF MIXING FLOOR. CHAFF COMING DOWN CHUTE FROM ABOVE.

£25, or an average of 9s. 7d. weekly. The quarterly energy consumption for power was :

June	369
September	746
December	665
March	631

The use of electricity from the farmers' standpoint means a considerable saving in labour, although the operations could be performed, as on many other farms, by oil or gas engines. Engine stopping and starting, however, requires time, and it would also be necessary to send men and carts for oil or coal to the nearest town or railway station, all of which takes time, and should be added to the cost of any other type of power, but rarely is taken into account.

There are many operations requiring power always to be found in agricultural areas, which are peculiar to the particular district.

Fig. 9 is a view of an old stone cider mill in Hereford used to crush apples, and the left-hand side electrical presses driven by a 10 h.p. motor.

Fig. 10 shows a portable pump used for filtering and racking cider. This portable pump is also used for shearing sheep, by a connecting flexible shaft driving the cutters to either side of the counter shaft-space, regulating being done by the controller in the motor starter.

Machines are used for the drying of spent apples after the juice has been extracted, and the apples afterwards used for cattle food ; one large machine of this description requires about 25 h.p., and runs for three months, twenty-four hours daily, with as few stops as possible. The same motor is used for sawing wood during other months of the year.

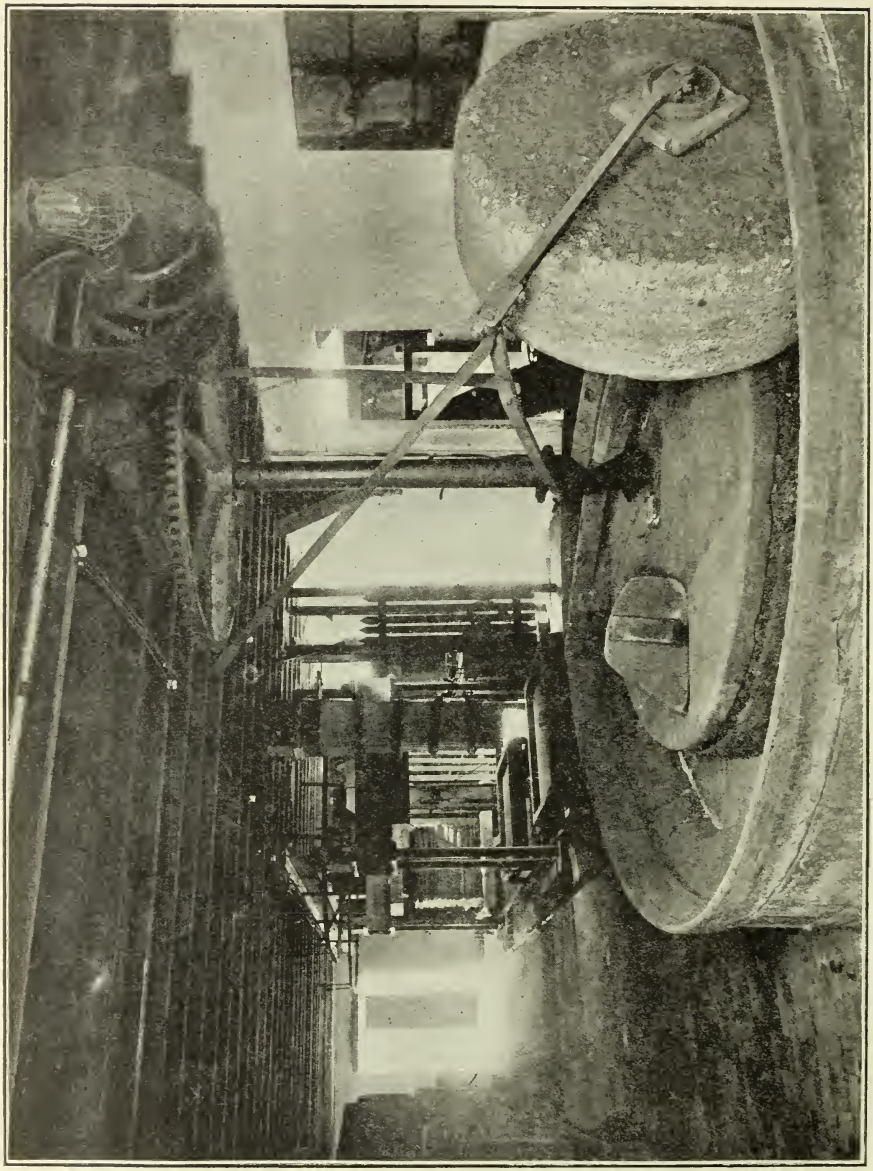


FIG. 9.—STONE CIDER MILL 200 YEARS OLD. 15 H.P. MOTOR.

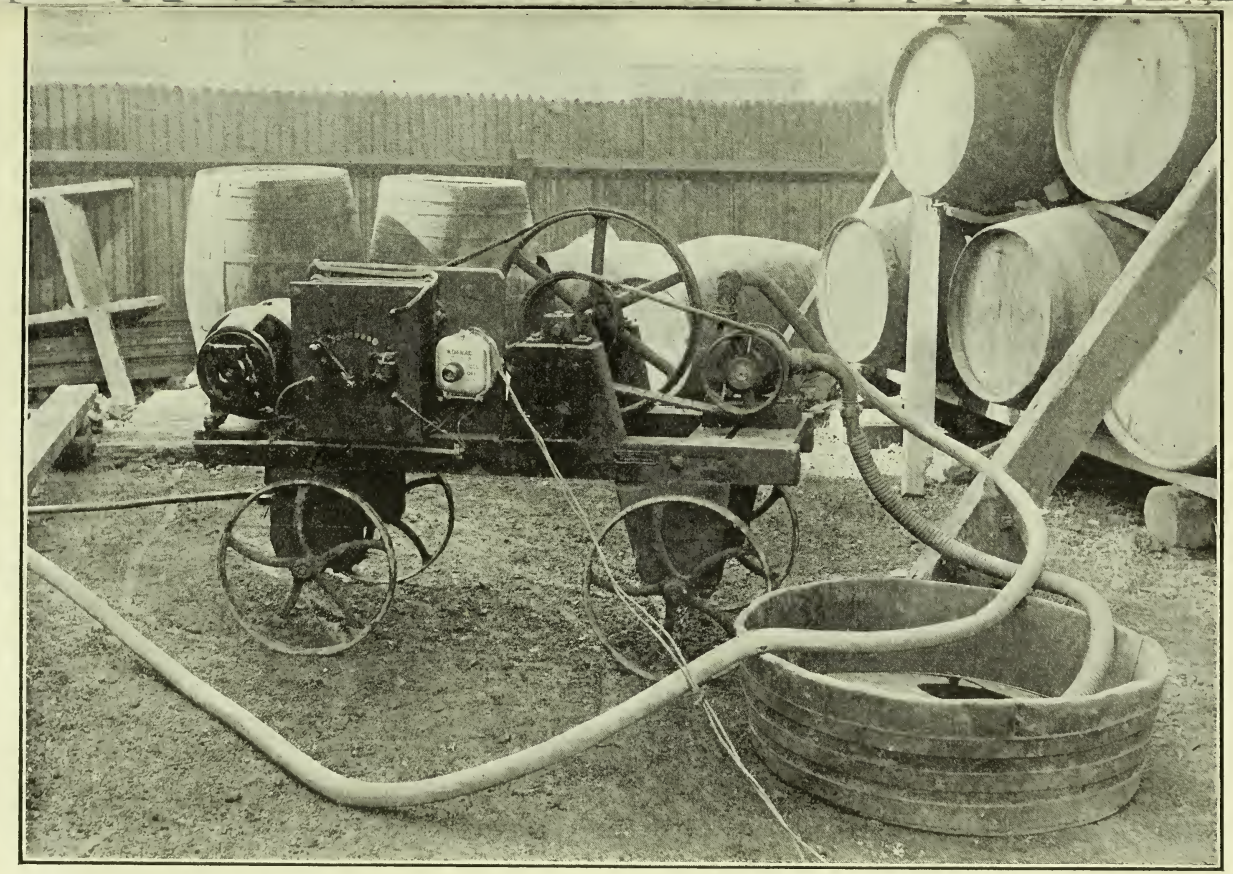


FIG. 10.—PORTABLE PUMP FILTERING CIDER FROM ONE CASK THROUGH FILTERS TO ANOTHER CASK. 1 H.P. MOTOR. THIS MACHINE CAN ALSO BE USED FOR SHEEP SHEARING.

Similar drying machines are used for grains and spent hops, the grain being used as a cattle food and the spent hops for bedding, while the seeds from the hops are used for the preparation of a dye stuff. Fig. 11.

In the greater part of the hop-growing district, the demand per farm would run up to 25 h.p., which would be used for spraying the hopyards, driving fans and pocket-filling presses; it is possible that electroculture would be of assistance in extinguishing blight, and this would open up a field of incalculable value.

Ploughing.—The introduction of electrical ploughing, and of electrically-driven wagons for the general hauling work is a possible development of the near future.

It requires about 1·5 acres of land to provide food for each horse kept on a farm, and the work being seasonable, at times many horses are needed for a few weeks together; and again there are many weeks when horses cannot be used owing to the land being in such a state due to weather conditions.

An electrically-driven plough or wagon would not be standing in a stable, eating its head off, and the elimination of horses would release further land for cropping. From a mechanical point of view, it would not be a difficult matter to design a machine that could be used alternately to plough, or to drive a thrasher, and which could be run into position to drive the general farm machinery. With a suitable pulley and geared counter-shafts for varying speeds, 10 to 12 h.p. would cover the power requirements for all usual operations, and the machine would be a farmer's "Mary Ann." But the vital necessity is a permanent power supply available in the farm, the rest would be simple, as no other form of power could be utilised in such a manner; the ordinary size of battery used on an electric vehicle would be sufficiently large to plough a good many acres of land,

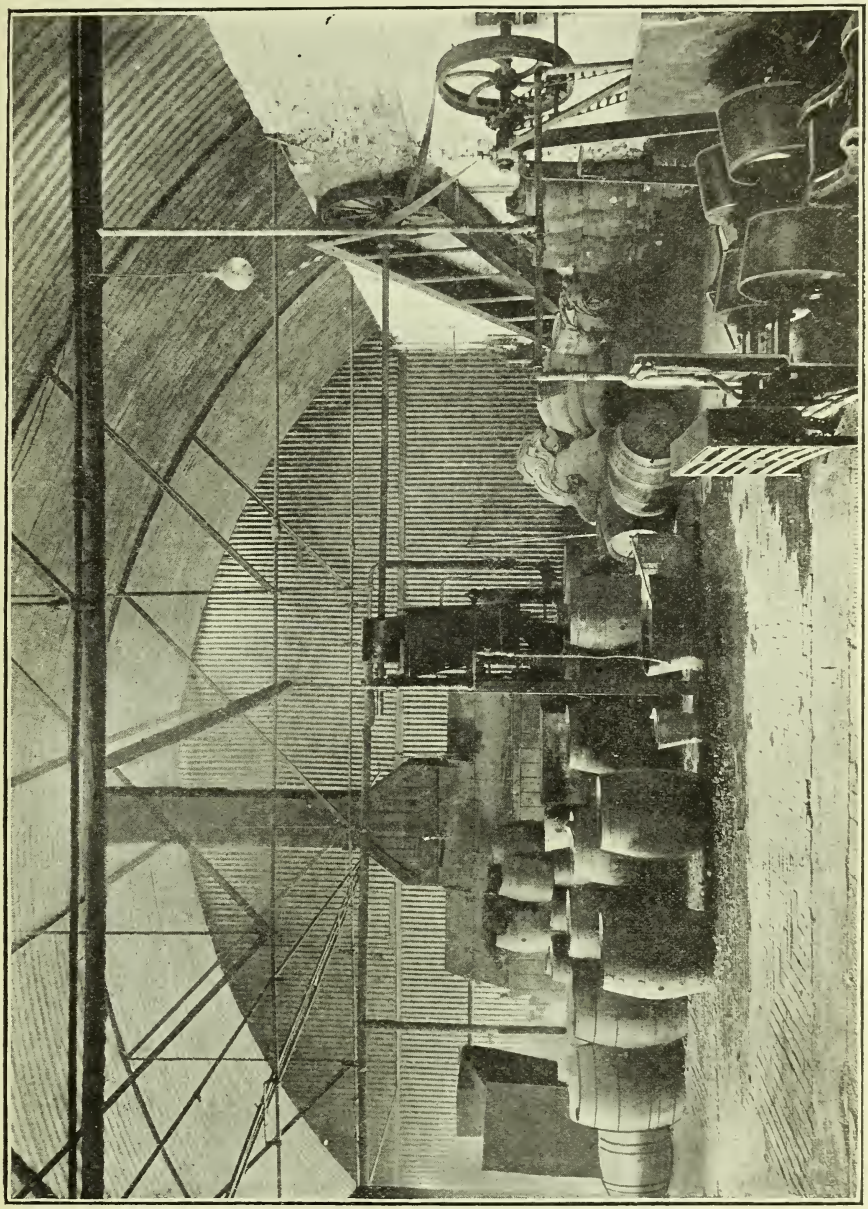


FIG. 11.—PLANT FOR DRYING GRAINS AND SPENT APPLES FOR CATTLE FOOD; ALSO BARREL WASHING MACHINE, 7·5 H.P. MOTOR,

and could be charged in the usual way at night, with a boosting charge during the day if necessary.

A petrol-driven two-furrow plough weighs about 20 cwt., and develops about 11 h.p., requiring about two gallons of petrol, or benzine, per acre, with a certain amount of lubricant. The total weight of a battery on a one-ton van, for a 50-mile radius, is about 1,260 lbs., giving a speed of 12 miles per hour ; the total weight of the chassis is 3,400 lbs., and if we substitute the plough blades for the weight of a pair of wheels and gear it to travel about 120 feet a minute, it would be fair to assume that a battery-driven plough is not an impossible machine.

The battery charge capacity being equal to 18 kw., the cost would be very low, at usual power rates, per charge.

There is little doubt that with charging facilities available, some persons would be enterprising enough to invest in such a plough and hire it out to farmers.

The *Electrical Review* of February 11th, 1916, contained a description of an electrical ploughing gear driven from overhead lines on a Nottinghamshire farm ; most farms have a certain area of arable land permanently used for cropping, round which light overhead lines could be erected to certain points, and by means of a trailing cable carried on a drum, geared with the speed of the plough to pay in and out (the cable being sheathed with tough rubber compound), the double winding rope hauling ploughing gear of the usual type could be dispensed with, and a plough carrying a single motor and controller used. Fig. 12.

The slow rate of speed of a plough along a furrow would not endanger the life of a trailing cable.

Electric ploughing on an extensive practical scale has been carried out in Germany, Sweden, Italy, and France, the results being usually stated to be in favour of electricity as

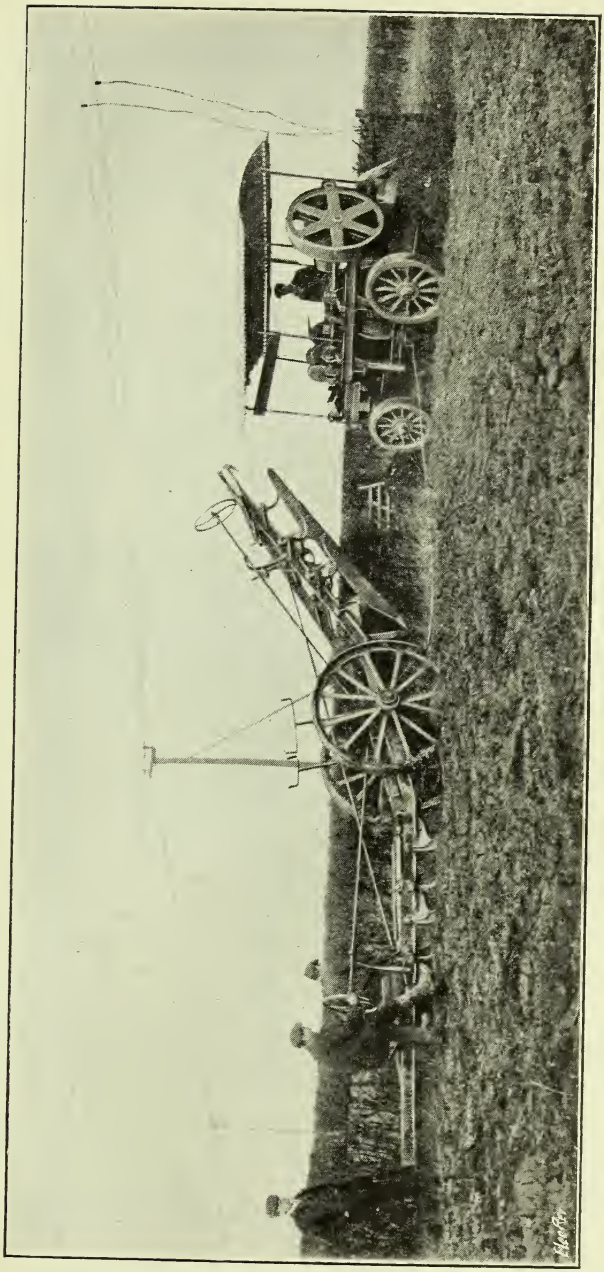


FIG. 12.—PLOUGHING—USING OVERHEAD DISTRIBUTION.

compared with either animal, steam or oil ploughing tackle. German investigators have declared that for really heavy ploughing, the only competitor of steam is electricity. Much of the published data regarding ploughing costs is, however, not really comparable, as the local conditions, depth of ploughing, etc., greatly influence the results obtained.

Agricultural Districts.—In the Hereford supply area, the district is typically agricultural. The horse-power of motors in use and units consumed generally in carrying out the operations are as follows:

Cider making	160 h.p.	67,404 units
Milling	142 h.p.	347,856 ,,
Farmers' supply	106 h.p.	19,673 ,,
Water pumping	157 h.p.	331,295 ,,
Sawmilling	130 h.p.	22,801 ,,

A curve of the daily output for one week is appended. Fig. 13.

A scheme of high-tension 3-phase supply has been prepared for the Hereford area, which it is proposed to carry out after the War, there being a growing demand for electricity from farmers and private residences that cannot be met by a 440-volt three-wire supply. There are as a rule five farms to the mile along an average road; there are also many ordinary country residences. We can estimate an average revenue of at least £100 per annum from the five farms, and anything from £20 to £200 from the private houses. Large country residences are only too anxious for such a permanent source of supply, and sixpence a unit could be quite easily obtained.

A few notes have been taken of the consumption and generating costs of several large mansions in the Hereford area, of which the following is typical:

The installation consists of engine (oil) of 16 b.h.p.; battery, 54 cells of 400 ampere hour capacity; 300 25 c.p. lamps installed

Average cost of " Royal Daylight " oil for twelve months, 10d. per gal. ; 2½ units of electricity delivered into house for every gallon used—4d. per unit for oil.

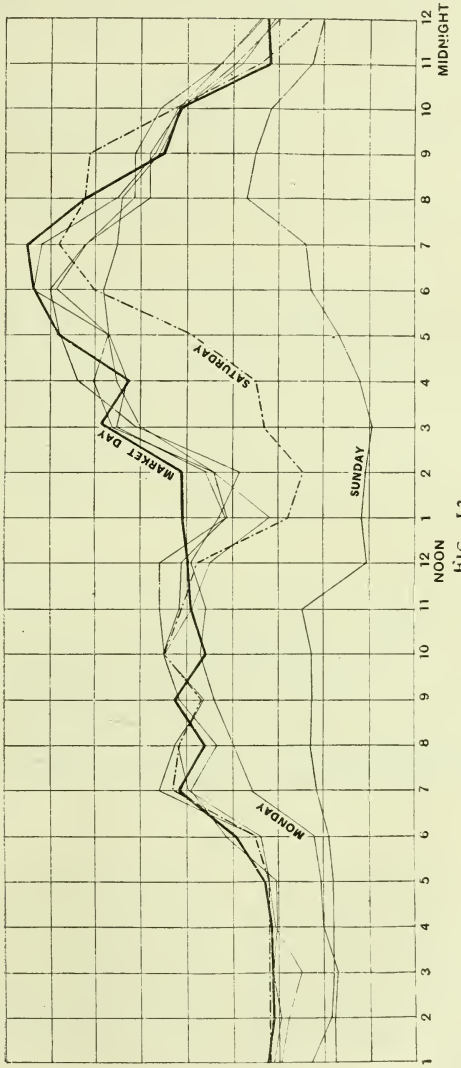


FIG. 13.

There were also 25 gallons of cylinder oil used at 3s. 2d. = £3 19s. 2d.

The cost of small repairs, battery, bolts, brushes, but not including repairs to wiring in the house, amounted to £4 12s. 3d.

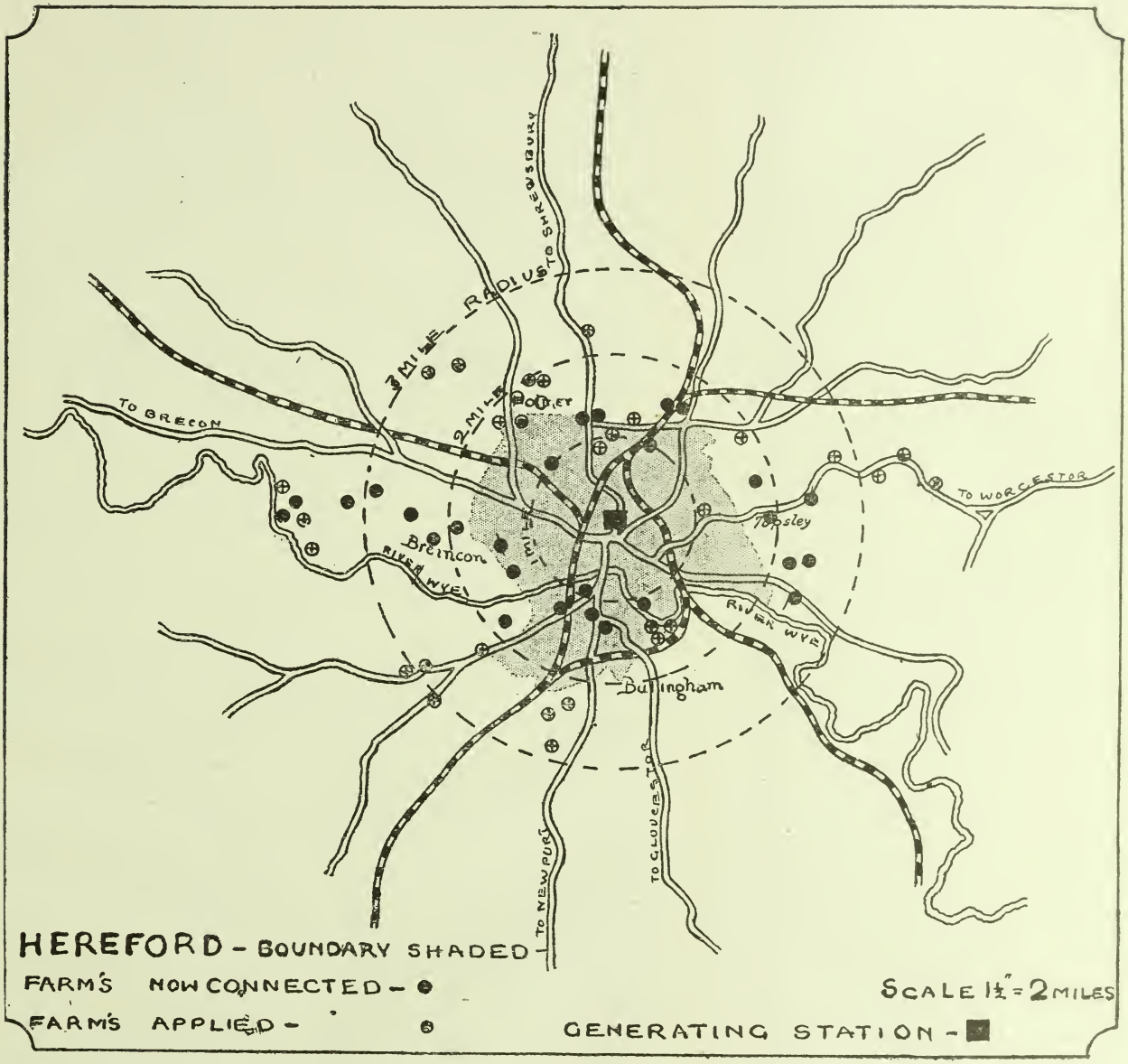
Wages of man to look after engine, etc., 28s. per week, plus house and coal, 10s. per week = £98 16s. 0d.

An allowance of 15 per cent. depreciation must be made on cost of the battery.

In all such private installations the current consumption could be increased considerably. It will be found that generally those responsible for running these small lighting plants deprecate the use of anything but lighting, and put as many difficulties in the owner's way as possible, with the result that for power and other purposes numerous small oil engines are being run in out of the way places, for instance, for water supply, ice making, stable work, etc.

Electric cooking and heating offer enormous possibilities if a permanent supply were available, and it is no exaggeration to say that such a supply will be received with open arms by the residents, who are under no misapprehension as to being able to produce electricity cheaper themselves. Such consumers have heard so much about the "battery will not do it," and paid so many repair bills, that they will take the first opportunity to get rid of the private generating plant.

The average revenue in such a case should amount to between £150 and £200 per annum; the owners in most cases would be quite willing to meet the cost of the service extensions, running over their own estates, from the main supply, or agree to a minimum charge of 10 per cent. on capital cost of extension, with a kilowatt demand and small charge per unit.


3 MILE RADIUS
2 MILE
1 MILE
TO SHREWSBURY
TO BRECON
TO WORCESTER
Brecon
RIVER WYE
Bullingham
RIVER WYE
TO NEWPORT
TO GLOUCESTER
HEREFORD - BOUNDARY SHADED
FARMS NOW CONNECTED -
FARMS APPLIED -
GENERATING STATION -
SCALE 1½" = 2 MILES

H.T. Supply.—In recent years a good deal of attention has been given to the future development of electric supply in this country on a wholesale scale, and some engineers—Dr. Ferranti and Mr. Chattock, for example—have pictured a future in which electricity supply will be run in the national interests, and the country will be served by a network of transmission lines. Such lines will in most cases have to pass through agricultural districts, which if properly exploited by the existing supply authorities, would be in such a state of development that a paying load could be obtained along the route to commence with.

In such a case it may be assumed that it would cost something like £2,000 to cut into the E.H.T. lines for a supply of low tension energy.

Existing data shows that the average consumption of current in an agricultural district with a population of 22,500 is 58 units per head, so that taking the county of Hereford as a whole, with a population of 114,296, the possible sale of energy on the same basis would amount to say 6,637,000 units.

This supply would be given in an area 40 miles long by 35 miles wide, with a central distributing point. Throughout England, towns of any size of over 20,000 population are 25 to 30 miles apart, with smaller towns of up to 10,000 people between ; this is the case in all the agricultural areas, and the distribution lines from most E.H.T. transformer stations would thus extend to about 15 miles radius.

It will be seen that the estimated output of 6,637,000 units, at an average price of 3d. per unit, would represent a revenue of £82,962, or taking as a basis the number of farms in the county—3,573 of an average of 150 acres—and allowing the same yearly revenue as already obtained from farms connected to the Hereford City supply, viz., £25, we obtain a revenue of £89,325 from farms alone. If the farms did not all elect to use electricity, there would still remain

numerous country houses and rural industries as available consumers, as well as village water supply and electric lighting installations. It is probable that the estimated consumption given would be exceeded.

As a matter of comparison, it may be pointed out that the South Metropolitan Electric Supply Company, during the year, had an output of 6,695,481 units sold, at an average price of 2·22d. per unit, and resulting in a total revenue of £62,068.

In this case, mains and distributing system would be a great deal more expensive in capital cost than a system composed of E.H.T. overhead trunk lines, radiating from a transformer station in four directions and interconnected by H.T. transmission lines, off which small transformers would supply individual farms and rural consumers; it would be much easier to sell the current in these districts than in large towns where there is competition in the form of gas supply and better railway facilities for coal and oil for generating power. Electricity would have a field to exploit alone.

Sir R. A. S. Redmayne, in his Presidential address to the "Institute of Mining and Metallurgy," insisted upon the imperative necessity of the conservation of coal by the prevention of waste in using it; he urged that the centralisation of production lies at the very foundation of progress towards the conservation of our natural stores of fuel. It is estimated that two-thirds of the coal consumed in industrial works is wasted, owing to the employment of obsolete and inefficient methods and plant. How much worse must this be where hundreds of wasteful little power producers are used in agricultural districts?

There are many other directions in which electricity is making headway in connection with agriculture which should not be overlooked, and the foremost of these is

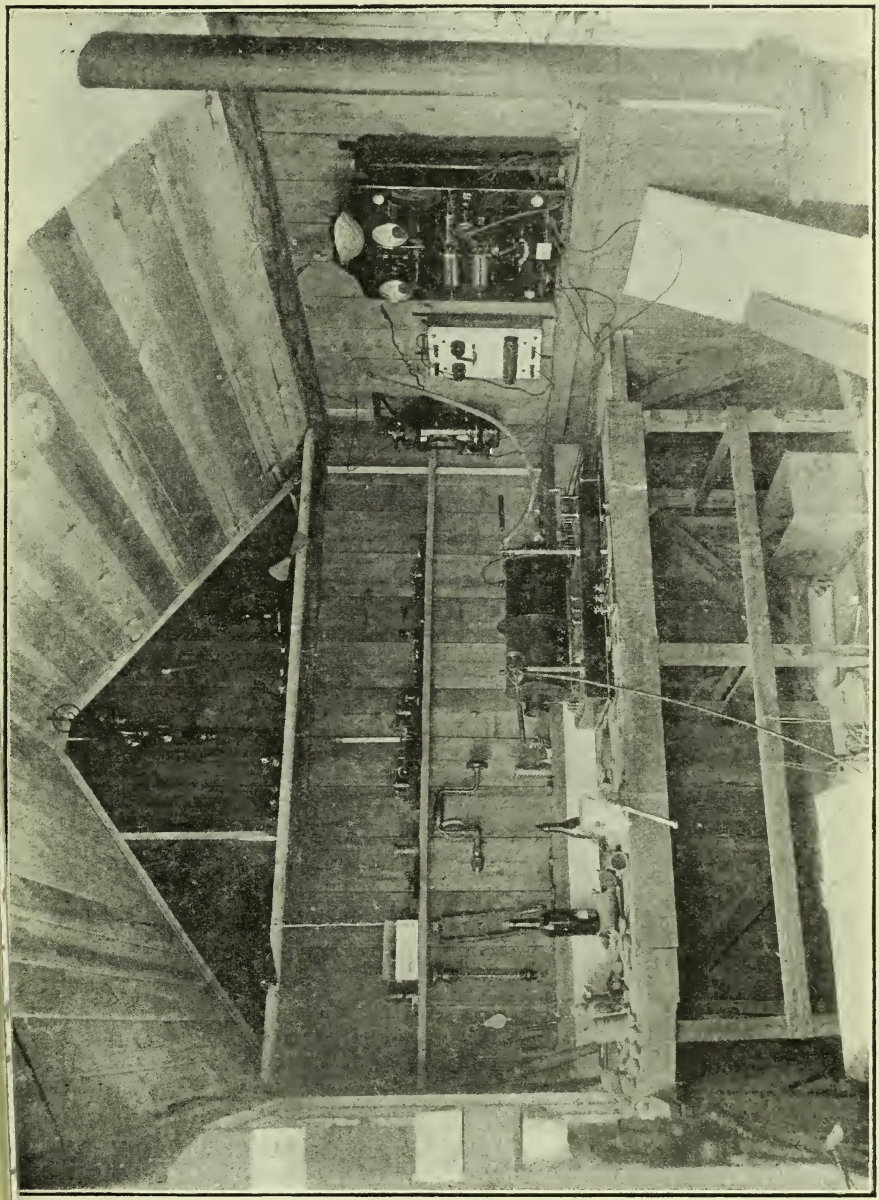


FIG. 14.—ELECTRO-CULTURE APPARATUS RUN FROM SUPPLY MAIN. AUTO CONTROL WITH TIME SWITCH.

" Electro-Culture." Experiments that have already been carried out have given most favourable results, notably those of Mr. J. S. Newman, of Bristol, and Miss Dudgeon, of Lincluden, Dumfries.

These were described by Sir Oliver Lodge in the Kelvin Lecture on " The Electrification of the Atmosphere," in March, 1914.

Miss Dudgeon is still carrying on her experiments, the current supply being obtained from a 30-volt storage battery used with a spark coil and rectifying vacuum valves ; these are, however, expensive instruments and quite out of the question for an ordinary farmer, besides requiring a certain amount of expert knowledge to get the best results. If a high-tension alternating supply were available, a small transformer with valves for rectifying and an automatic time-switch for controlling would be less costly, and could be built up in such a manner that it would be quite safe to place it on any farm. The current consumption alone would not be great, but the increased yield per acre of food-stuff would be of the utmost value to the country. (*See* Appendix A.)

Results on Potatoes.

For the first three years, 1912, 1913 and 1914, the crop experimented on was potatoes, with the result that each season there was a considerable difference between the weight of the crop lifted off the electrified and un-electrified areas.

For the purpose of weighing with the greatest accuracy the two plots were divided into spaces measuring one-tenth of an acre each. The tubers were put as lifted into sacks, and weighed on scales which were placed near at hand.

The following table may be of interest as showing the increase in yield of tubers lifted under the discharge wires over those from the control :

1912 (Electrified)—10 cwt. 3 qtrs. 5 lbs. more per acre than control.
1913 (Electrified)—13 cwt. 3 qtrs. 21 lbs. more per acre than control.
1914 (Electrified)—1 ton 3 cwt. 2 qtrs. 1 lb. more per acre than control.

The first year the potatoes were grown on ground in proper crop rotation, 12 tons per acre were lifted from the electrified portion. This was considerably higher than the average for the district.

The total acreage under potatoes in the United Kingdom, as given in Agricultural Produce Statistics, was for years 1911 to 1913, 1,200,000 acres, and the average yield per acre 5 tons 7 cwt. The average price in those years would be about £3 10s. per ton. It is now £7.

Conspicuous Difference in Oats.

Last year, 1915, the crop chosen for experiment was oats, which was grown on the same field as used in previous trials for potatoes.

The season was an exceptionally dry one, there was a scorching sun, and the field being of a gravelly nature, devoid of all shade, these combined conditions were not conducive to harvesting of a heavy crop.

From the very commencement of the growth, the oats under the electrified network showed a conspicuous difference in comparison with the un-electrified, and did not suffer from the prevailing drought to the same extent ; which fact seems to confirm the theory suggested by Prof. Lenstrom, that the electrified current causes an ascent of liquid in the capillary tubes of the plant, and by means of this attraction it is quite possible that these tubes obtained

moisture from a lower stratum, which the plants not under the discharge were unable to do.

When the crop was ripe for harvesting the two plots were cut, thrashed and weighed separately, showing the remarkable difference of 31 per cent. in grain, and 63 per cent. in straw, in favour of the electrified oats.

The subject of electro-culture is still in the experimental stage, but it may be remarked that the majority of the numerous investigators in this field are optimistic as to the future, and more than one foreign Government is officially investigating the matter. From the farmer's point of view the first cost of the installation appears to be the dominating factor, while so far as the central station is concerned it must be admitted that the power requisite would be comparatively small—Mr. J. E. Newman estimated that 1 h.p. would be sufficient for fifty acres. The fact of electricity being required for such a purpose would, however, inevitably lead to its adoption for lighting and power purposes.

Some of the other uses of electricity in agriculture are the incubation of chicken. This was described by T. Thorne Baker, Esq., F.C.S., in the *Daily Mail* of July 1st.

Electric Chickens.

Perhaps the most commercial proposition of all is chicken culture, an industry rapidly gaining in importance in England. Eggs hatched in incubators sometimes yield a percentage of weakly chicken, so that many young chicks die during the first few days.

The application of suitable high frequency current for the chicks almost entirely prevents this death, owing to its stimulating effect, while they gain weight on their normal amount of food at an increased rate, becoming in two months as heavy as chicken grown for three in the ordinary way.

They get their second feather very early, and are obviously finer birds. A chicken farmer growing "petits poussins" for the epicure's table—a commerce of noteworthy profit—could thus produce nearly 50 per cent. more chickens per annum at a cost which works out very much lower than the cost of providing the electricity.

*Electric Incubation.

The electricity supply companies of America are nothing if not practical. They believe that in order to promote the sale of electricity it is necessary to inspire a customer with a reason for the faith that is in him with regard to the advantages of electricity applied to the every day needs of the community. As a large proportion of the customers of electric light and power companies throughout America are situated in rural districts, the attention of both electrical apparatus manufacturers and electric supply companies has been directed very specially to the problems attending the application of electric power and lighting to the needs of farm life. Bearing this point in mind, it is interesting to refer to a demonstration which has recently been given by the Kentucky Electric Company, Louisville, for the purpose of demonstrating to the public generally the advantages of electric heating for incubators. In order to effect this a show window was set apart for the demonstration, and it naturally attracted a very considerable degree of attention, as it was situated in a position easily available to the general public.

A "Cyphers" electric incubator with a capacity of 120 eggs was used. The incubator was set on February 27th, with its full complement of eggs, and on the seventh day of incubation the first test was made, and eleven imperfect eggs were discarded. The demonstration was carried out by Mr. Eugene Strauss, proprietor of a well-known poultry farm, and White Wyandotte eggs were used. Mr.

* *Electric Review*, August 1st, 1913.

Strauss devised a rather ingenious appliance, with which he obtained satisfactory tests on the eggs, with the result indicated. Three of the eleven eggs displayed dead germs, while the remainder showed up as unfertile eggs. The second test was made on the twelfth day of incubation, when again eleven eggs were discarded, the test revealed that each egg contained a dead embryo, showing that the eggs in this case were originally fertile. It was easy to find an explanation of this catastrophe, however, as a section of the incubator was for a few hours on the preceding day subject to the direct rays of the sun through a heavy plate-glass window. As a result of this increased temperature the eleven eggs were literally cooked. This left ninety-eight eggs in the incubator at the hatching period, which began on the twentieth day. A rather remarkable record of eighty-six chickens emerged from the shells during the two days of the period. Unfortunately this success in itself proved the cause of another disaster, as owing to a failure to relieve properly the congestion in the hatching drawer of the incubator, twenty-one of the chickens were smothered before they dropped into the warming chamber at the bottom of the incubator. This left sixty-five chicks, which were placed in the brooder and kept in the window for four or five days, as an exhibit of the success of the undertaking. Only two chickens died in the brooding pen.

The temperature within the incubator was started at 101° F., and increased on the second day to 103°. The purpose was to keep the temperature as close as possible to the latter figure, and only for a few hours did it vary from this point. The minimum was 101½°, and the maximum 105°, in these fluctuations. The hydrometer varied during the period of incubation from 52 to 67, and the outside temperature ranged from 56 to 74. The total energy consumption of the whole period was 14 kw. hours.

According to the *Electrical World*, the great sheep ranches in the stock-raising regions of Oregon are large consumers of electricity for light and power. Central station energy

is used for pumping in the irrigation districts and for chopping grain for stock feed in the winter.

In one of the stock-raising farms, electricity has been put to a novel use for the winter fattening of sheep.

The sheep pens are wired, and the electric light is turned on during the winter months from 4 p.m. to 9 p.m. Under this artificial illumination the sheep continue to feed until the lights are extinguished ; at 4 p.m. the lamps are again turned on and then burned until daylight, and again the sheep feed.

In this way the sheep are made to feed during the equivalent of a long summer day, and thus, despite the winter season, are brought quickly to the condition for marketing.

The foregoing notes represent only a brief outline of the possible directions for electrical development in connection with agriculture. No reference has been made to the domestic uses of electricity on the farm, which will almost certainly exceed those of the town consumer ; nor has any mention been made of future developments in connection with the production of artificial fertilisers by electrical means.

For the moment it is sufficient to point out that electric power and light appeals so strongly to the agriculturist that but little exertion would be required on the part of the central station authorities to secure a really profitable business.

The writer feels, however, that successful as individual efforts might be, the results obtained would be insignificant compared with those which might be secured were an organised campaign in favour of agricultural electrical supply to be instituted, and efforts made to equip demonstration farms in suitable districts near existing towns.

The writer hesitates to add to the many activities of this Association, by suggesting additional responsibilities—

especially at the present time—but there is no doubt that its members have the matter in their own hands, and that concerted action is strongly called for, both for private reasons, to frustrate the efforts of the oil-engine makers to monopolise the farmer's power business, and on national grounds, because it is imperative that no effort be spared in obtaining the mutual support of our industries with a view to securing the maximum of industrial efficiency after the war.

APPENDIX A

In England and the U.S.A., the bulk of the spirits produced is manufactured from grain. This was also the case in Germany one hundred years ago, but now, in that country, the bulk of the spirits is produced from potatoes, which give a heavier and cheaper yield of starch per acre, than any other vegetable, and enable a very pure spirit to be easily obtained. In Germany, too, the manufacture of spirits is of very great benefit to agriculture, for it is carried on by mutual co-operation of farmers, who sow their own potatoes and then cart them to a joint owned distillery, where they are converted into alcohol in the winter months (up to May), while spent wash and residues, rich in nitrogenous matters, is utilised as a cattle food on the farm.

In 1906 no less than 71,000 of these so-called " farmer distilleries " were in operation, also about 1,000 industrial distilleries, usually situated in or near a town, specialising in the manufacture of yeast.

There seems to be no special reason why this same work should not be carried out in this country, and every farmer distillery would be a source of revenue, and electro-culture would increase the propagation of the crop of grain or potatoes, the cost, taking electricity at 3d. per unit and allowing 20 to 30 watts per acre, being estimated at 5s. per acre per annum.

LIST OF REFERENCES MADE TO ELECTRICITY IN AGRICULTURE IN THE "ELECTRICIAN."

Date.	Page.	Name.
December 17th, 1915	397	Power in Agriculture.
July 16th, 1915	536	Electricity in Farming.
December 19th, 1913	442	Experiments in Electro-culture, by H. C. Dorsey.
September 26th, 1913	1024	Electricity in Agriculture and Horticulture.
April 4th, 1913	1169	Electricity on the Farm, by P. A. Bates.
July 19th, 1912	601	Electricity in Farming.
February 2nd, 1912	688	Electricity for Farmers.
November 3rd, 1911	157	Electricity in Farming Work.
September 8th, 1911	871	Electricity in Agriculture and Horticulture.
September 22nd, 1911	918	Electric Power and the Farmer.
March 17th, 1911	915	Electricity as applied to Agriculture, by J. E. Newman.
February 17th, 1911	730	The "Motor Drive" on a Farm.
March 24th, 1911	934	Electric Pumps in Horticulture.
June 10th, 1910	351	Electricity in Agriculture.
September 16th, 1910	956	Electricity for Farming Work and Irrigation, by H. Russell.
December 7th, 1909	378	Electricity in Agriculture.
April 16th, 1909	29	Electricity in Agriculture and Horticulture.
June 18th, 1909	397	Electricity in Horticulture.
July 2nd, 1909	480	Electricity in Horticulture.
February 26th, 1909	777	Electricity in Agriculture.
March 26th, 1909	913	Electricity in Horticulture.
December 11th, 1908	358	Electricity in Horticulture.
June 26th, 1908	523	Electricity applied to
July 17th, 1908	415	Electricity in Agriculture, by Sir Oliver Lodge.
January 17th, 1908	503	Employment of Electricity in Agriculture.
March 20th, 1908	862	Electricity in Agriculture.

LIST OF REFERENCES MADE TO ELECTRICITY IN AGRICULTURE IN THE "ELECTRICAL TIMES."

Date.	Date.
April 13th, 1911.	August 22nd, 1912.
April 20th, 1911.	August 21st, 1913.
September 7th, 1911.	November 27th, 1913.

September 2nd, 1915.

LIST OF REFERENCES MADE TO ELECTRICITY IN AGRICULTURE IN THE "ELECTRICAL REVIEW."

Date.	Page.	Subject.
November 4th and 25th, and December 2nd and 16th, 1898	—	Professor Lemstrom on Electro-culture.
July 17th, 1908	116	Electricity in Agriculture, by Sir Oliver Lodge.
April 23rd, 1909	687	Note on Electro-culture.
October 1st, 1909	556	Electricity in Agriculture.
March 25th, 1910	475	Note on Electricity in Agriculture.
April 8th, 1910	573	Note on Electricity in Agriculture.
April 29th, 1910	705	Note on Electricity in Agriculture.
September 2nd, 1910	385	Electro-culture.
October 14th, 1910	637	Electricity on the Farm.
March 3rd, 1911	371	Note on Electric Ploughing.
May 26th, 1911	864	Note on Electric Ploughing.
August 4th, 1911	184	Electric Threshing in Switzerland.
October 27th, 1911	707	Portable Motor for Agricultural work.
November 10th, 1911	807	Portable Motor for Agricultural work.
January 26th, 1912	157	Electricity and Plant Growth.
August 23rd, 1912	301	Electric Farm in America.
October 4th, 1912	552	Electricity in Agriculture.
November 22nd, 1912	839	Note on Congress of Electro-culture in France.
January 24th, 1913	123	Note on Electro-culture.
September 20th, 1913	518	Electro-culture with the Cooper-Hewitt Lamp.
December 19th, 1913	1015	Electro-culture, by T. T. Baker.
July 31st, 1914	169	Electrical Treatment of Milk.
August 14th, 1914	256	Note on an Electrical Farm.
October 9th, 1914	508	Electric Ploughing.
December 11th, 1914	798	Electricity on the Farm.
February 5th, 1915	185	Note on Electrification of Hens.
June 4th, 1915	796	Electricity in Farming.
June 11th, 1915	837	Electricity in Farming (Hereford).
June 18th, 1915	869	Electricity in Farming.
June 18th, 1915	862	Note on Electrical Incubator Tests.
December 3rd, 1915	729	Electricity in Agriculture.

DISCUSSION.

Councillor Langford (Hereford), thanked the Association for giving him as a farmer an opportunity of expressing his views upon this question. He also wished to support Mr. Kerr in his excellent endeavours to extend the use of electric current to farmers in the Hereford area. Perhaps it would assist the meeting in understanding his position if he told them, as a farmer, what power he was using at the present time and how he had applied it to agriculture on one of his farms. To begin with he was driving a milking machine for milking about 70 or 80 cows, he was driving a chaff cutter, which, in addition to cutting the food for the milking cows in winter, also cut the chaff for 150 bullocks and a flock of about 600 sheep. He also pulped the mangolds and swedes, crushed the cake and corn necessary for feeding the animals, and, lastly, he had put in a very small motor for the purpose of pumping water from a deep well, whilst during the season that had just passed Mr. Kerr had adapted for him some sheep shearing apparatus in conjunction with a portable motor. In addition, he was lighting the whole of the farm buildings and also a yard known as "The Fold" outside the farm buildings by electricity. He was also crushing apples and pressing the juice from them for cider making and filtering the cider. Before he adopted electricity for filtering, he used to have to draw the cider from various long distances in the cellars in the yards to the fixed engine before it could be put through the filter. Now, however, he was able to take the portable pump and motor wherever he required it for filtering the cider. When once you have an installation on your farm you can do almost any work with it anywhere, by means of a portable motor and cable. He wished to impress upon electrical engineers the great field there was for the development of electric power in connection with agriculture. These were some of the things he was doing, but, unfortunately, many of his farmer brethren were deprived of these facilities by reason of being more distant from the power station. At the same time, although he was perfectly satisfied with what he was now getting from electricity, he wanted something more. He wanted to plough the land, especially as in the present national crisis there was being abstracted from farm work a large number of our youngest and best skilled farm labourers. Yet the Board of Agriculture was impressing upon farmers to do all in their power to produce as much food as possible from the land. Consequently, it was

essential for electrical engineers to come to the assistance of the farmer in the way that Mr. Kerr had shown had been possible at Hereford. As he said, he wished to plough the land and till it, mow the grass, reap the corn and haul it home by motor, and what perhaps was more important, he wished to snap his fingers at a dry season and take the motor down to the river or brookside and irrigate the land and make it more productive than it could possibly be in a dry season at present. It did not matter how rich the land was if prolonged periods of drought came, the crops would suffer for want of moisture. All this could be overcome by introducing electric power into our rural areas. He also had at a distance of 5 miles from the electric power station a fruit-growing and market garden farm, as yet no electric power is obtainable here. He had planted within the last ten years over 10,000 apple and plum trees in addition to 40,000 blackcurrant bushes, and those who knew anything of rural life knew that one of the greatest things to be combatted was the insect pest known as blight. If all the rural areas of the country could be supplied with electricity, then trees could be washed more expeditiously than there was now time to do, and a very much greater crop of fruit would be produced. Mr. Kerr had said something in the paper about electro-culture, and if the war had not broken out, Mr. Kerr had intended to fix up an apparatus with which some severe tests would have been carried out. Unfortunately that had been abandoned until after the war. During his twenty-four years' experience as a farmer he had always had the advantage of steam power, but as the petrol engine became more efficient, he scrapped the steam engine for the petrol engine. Other farmers had not yet scrapped their steam engines for the petrol engine, because they anticipated big developments with electricity and were hoping to save the expense of the oil engine by taking electricity very soon. He was glad to be rid of the steam engine because it was a very thirsty, hungry, noisy, smoky, and dirty thing, and there were many operations connected with agriculture that could not stand any of these things, particularly in the production of milk. He could hardly, perhaps, speak strongly and badly enough about the oil engine from this point of view. They were difficult things for inexperienced persons to handle, and had a curious knack of jibbing just when they were wanted to start up quickly. On the question of cost, he would remind them that farmers were very poor, and had to look at every penny they spent, and, therefore, anything in the shape of electrical apparatus that was offered must be at a price which paid the farmer to substitute it

for steam or oil. At present he believed it was possible to procure an electric motor for something like half the cost, power for power, of a steam engine or an oil engine, and the question of cost was the first thing that would grip the farmer. Another advantage of the electric motor was that an engine driver was not required, and he instanced a case of a farmer friend who was compelled to go to the expense of an engine driver because he had a suction gas engine plant, and incidentally experienced considerable trouble with it. It was well known, of course, that high wages were not paid in the country, but a driver of an engine would at least cost £78 per year, or perhaps 30s. per week with a cottage thrown in. He had had the advantage of avoiding this by being fortunately in close proximity to the electric power station. Yet another advantage was the great reliability of electric motors, for during three years' use nothing more serious had happened than the blowing of the fuse. Then there was no contamination of the milk, and thus the farmer was assisted in despatching his milk quickly under the most clean and hygienic conditions. On the question of cost too, a point that appealed to the farmer was, that although he might be using a 8 h.p. motor, if he only required to deal with a 2 or 3 h.p. load, the larger motor only took the amount of current for the particular load. The advantages of electric light were possibly even greater than the advantages of electric power to the farmer. It anticipated the Daylight Saving Bill so far as the farmer was concerned, and extended the shortest day in winter by about three hours. He had actually had one man give him notice to leave because of this extension of hours, the man saying that he had never worked so many hours in the winter in his life. The use of electric light in the farm buildings enabled much preparation to be done before the actual milking time, such as preparing the food for the cattle, and so on, whilst a curious thing was that during the time animals were fattening, by turning on the lights in the yard they fed after dark just as if it were daylight, whereas in the darkness they would not feed. Thus the animals were got ready for market at an earlier date. As a dairyman there was another advantage in that the use of electric light prevented contamination of the milk from the paraffin lanterns usually used. No matter how careful the men were, the oil from the lanterns always seemed to cause trouble with the milk, but this was avoided by the use of electricity. In connection with these advantages to farmers, he thought the problem of linking-up which had been discussed on the previous paper, had considerable importance.

Mr. F. Ayton (Chief Electrical Engineer, Ipswich) said the paper would be of the greatest possible utility to all those who were endeavouring to get an agricultural load for their undertakings. It was such a good paper that he felt diffident in offering any criticism, but he did not agree with the author on the question of electric ploughing. It was proposed to use a battery-driven plough, but he did not think for a moment that that was going to be successful, for the reason that in ploughing the land the amount of power required for turning over the land varied immensely with its nature, and with very heavy land a very much larger amount of power could be used. The battery would have to be of a size quite out of proportion to what one would consider suitable for carrying about the farm. This paper again raised the question of wayleaves, and he was afraid not very much would be done in the way of supply to rural areas until more reasonable legislation was passed in regard to this matter. The Association might do some good by again pressing the Board of Trade in this connection, because there was a better reason now, having regard to the Board of Trade Circular relating to linking-up. Those stations which at present generated continuous current, however, could not hope to do very much in the way of getting agricultural supply unless they changed to alternating current supply. From experience he could say that it was quite easy for every continuous current station to tack on, so to speak, a three-phase high tension supply and start it in a fairly small way. He had done so, and had found the use of the inverted rotary converter with automatic voltage regulation quite satisfactory. In order to get the agriculturists to make the demand for current, however, it was necessary to recognise that they must be educated, and for this purpose the local Press should be largely used, whilst the remarks made so ably by the Councillor from Hereford should be quoted extensively.

Councillor E. R. Dymond (Hereford), referring to the map of the Hereford area in the paper, said there were 56 circles, of which 19 were connected to the mains and the other 37 desired to be. So far as Hereford was concerned, it was not necessary to educate the agricultural population, because they simply came to the Department and howled for current. On the question of whether it was worth while to take this load up, it was necessary, in his opinion, to make some comparison of the agricultural consumer with the ordinary consumer. In Hereford, by leaving out four large consumers, there were 983 ordinary con-

sumers, bringing in on the average £5 12s. per annum. On the other hand, the 19 agricultural consumers brought in about £25 each per annum, so that as far as that was concerned the load was well worth cultivating. There was, moreover, no reason why the revenue from farms should be greater in the Hereford district than in any other. The difficulty of extensions in Hereford was wayleaves, and these difficulties at times were so great that it almost made one drop the business. He suggested that all electrical undertakings should get into touch with their local agricultural societies, which existed practically all over the country, and get them to pass resolutions in favour of a supply of electricity in bulk being more easily obtained, and to send these resolutions to the Board of Agriculture, and from the Board of Agriculture to the Board of Trade. Then there might be some reasonable chance of getting the very antiquated and absurd regulations regarding wayleaves removed. Special attention should be given to the question of increasing production by electrical means, because no farmer would go to the expense of putting down his own electricity producing plant, notwithstanding that results obtained hitherto had been exceedingly gratifying. Finally, he suggested that careful consideration should be given to the question of the price charged to the farmer from the point of view of the value the current had for the purpose in hand, namely, increased production by means of extra H.T. discharge. Whereas in 99 cases out of 100 an ordinary consumer took energy merely because it was convenient or cheap or perhaps both, in this case, electricity was *the* form of energy, and the only form which would do the job, and the financial result to the farmer was out of all proportion to the cost he paid for the current. In the case of potatoes, for instance, which before the war produced £3 10s. to £4 per ton, it had been successfully proved that something approaching a kilowatt of demand would deal with 50 acres, and that 23 additional cwt. per acre could be obtained. This at the ordinary prices would give approximately an additional profit of £200 for an expenditure of about 28 units per week for three or four months, a ridiculously small expenditure of current. Farmers did not use the current when the sun was shining nor in the hours of darkness, but just during the hour or two after sunlight. If electrical engineers were going to produce for the agriculturists of the country these extra profits, they were entitled to a little more than 15s., 16s., or £1 in current, even at the maximum rate of 8d. per unit, and therefore he argued that some steps should be taken to make the charge proportionate to the result produced.

There ought to be legal power to do this, although at the same time the electrical undertaking could be trusted not to make such a charge as would in any way kill the business. Another reason why the charge should be higher was that for a good many years a great deal of technical advice would have to be given by the supply station engineers to the farmers with regard to the plant which they would probably also have to keep in repair. Generally speaking, the central station engineers would have to father that kind of use of electricity, and for this reason he suggested that the charge should be a little more than 8d. per unit.

Mr. W. B. Woodhouse (Yorkshire Electric Power Company) said one advantage to the farmer not mentioned by Councillor Langford was the considerable reduction of fire risk. From the supply undertaking point of view, of course, wayleaves were really difficult, and he was glad that so many speakers had suggested that the Association should deal with this matter. It could be dealt with much more effectively when the farmer had been persuaded that it was necessary that he should have electric power. There were a great many small farms in Yorkshire using electricity, and they were connected in some cases to the 10,000 volt overhead lines by means of a pole transformer, and it was very much easier to get wayleaves from the farmer who wanted to use electricity than from the farmer who did not. Another tremendous advantage to the farmer of an extension of the use of electric power was the reduction of smoke nuisance. The Yorkshire Agriculture Council had gone into this matter very carefully to find out how far smoke travelled from big towns, and what effect it had on the vegetation. Taking Leeds, it was found that in the centre the annual deposit of sooty matter from the atmosphere in one year was 1,886 lbs. per acre. Four miles away from Leeds it fell to 177 lbs. per acre, but the smoke effect travelled much further than that. The effect of burning coal in domestic and factory chimneys was to make the air acid, and a further series of experiments was carried out by growing vegetables and showing the effect of watering these with water collected at various distances from the smoke centre. All the vegetables were grown in the same soil, and it was found that whereas the average weight of a lettuce in Leeds grown under these conditions was 44 grammes, one mile away but still in the town the weight increased to 56 grammes. Three-and-a-half miles away in the residential suburb it increased to 120 grammes, and six-and-a-half miles away at the University Farm, it was

175 grammes. The whole difference in the growth was due to the smoke, and the smoke could be got rid of if the use of electricity was extended on the lines that the Association had been discussing that afternoon.

Mr. S. E. Britton (Member of Council) (Chief Electrical Engineer, Chester) referred to a farm of 500 acres to which he had supplied electricity for eighteen months. Eighty-five acres produced corn at a value of £850 and corn to the extent of £1,005 was purchased. Thirty acres grew 600 tons of roots.

The whole of the above was either cut or chopped up for 200 head of cattle and 300 sheep.

Water was pumped for the requirements of the farm and house.

The original equipment was a portable engine and boiler, which supplied power for corn crushing, wood cutting, etc., and the cost per annum for the fuel alone was £33.

Since the farm has been equipped electrically, the total cost was £23 per annum, at 1d. per unit, and the farmer was delighted with the results.

Mr. W. C. Bexon (Member) (Borough Electrical Engineer, Kilmarnock) referred to a sixty-light installation in addition to a 12 h.p. motor connected up to his mains, the annual revenue from which was between £15 and £19. The reason why this particular farm was connected up was due to the difficulties in obtaining wayleaves for carrying the transmission wire further on, and it was found that the only way to get this permission was to equip the farm for the farmer. He adopted the same arrangement as Mr. Woodhouse, namely, a pole transformer, and the farmer had found the working costs to be much cheaper than oil, particularly now that labour was very short. Altogether he had five farms which were working electrically.

Mr. W. Burr (Member) (Chief Electrical Engineer, Swansea) asked if electro-culture had the effect of working out the ground more quickly.

Mr. S. E. Fedden (Past President) (Chief Electrical Engineer, Sheffield) speaking with regard to electric milking machines, asked if these had the effect of milking out the cow more completely.

Councillor Langford, replying to the last two questions, said that the effect of electro-culture was to draw out the ammonia from the air, and in that way the necessary constituents were put back into the land immediately. In other words, it was only necessary to pay rent for one piece of land and the rest could be very easily done. The modern milking machine did not have the effect suggested by Mr. Fedden, although that had been experienced with the earlier ones.

A hearty vote of thanks to Mr. Kerr closed the meeting.

Mr. William Low (Marykirk) (*communicated*), says he read the paper with very great interest, as for a number of years he has been using electricity for several of the purposes on which Mr. Kerr writes. He had a small water power, which he improved some ten or twelve years ago, and used electricity as the means of carrying the energy developed to places where it could be most conveniently used.

The maximum distance to which current was taken was fully 2,000 yards ; but as he had only 25 h.p. when there was a fair flow of water in the stream, there were times during the recent dry summers that the plant was idle.

In order to develop to the greatest extent the use of electricity, either in agricultural work or in a country house, the supply must always be available, and that can only be guaranteed by an electrical supply company with a sufficiently large supply station and enough consumers to make the load fairly steady.

Mr. Low has found the overhead system of transmission satisfactory, except where the line passes through a wood, and there he found it desirable to run the leads underground. The overhead conductor carried through his own ground consists of six strands of No. 4 hard drawn bare copper wire at a height of 16 feet or thereby from the ground ; the average distance between poles is 65 yards.

On the farm he uses electricity for lighting buildings and cottages, and for threshing, for which purpose he finds a 15 h.p. motor running at 660 r.p.m. ample to drive the mill and the straw-carriers which convey the straw to the barn. He reckons the power required for this work averages 10 h.p.

It is usual in this part of Scotland to fill one's straw barn when arrangements have been made to thresh, but it is an advantage for feeding to have freshly-threshed straw, so he deals with ten days' supply at a time, say, a stack of oats, and another of barley.

Mr. Low also uses electricity to operate a cream separator in the dairy, an operation which takes from twenty to thirty minutes ; and enables the dairymaid to be doing other work while an arduous duty is being performed by a small motor taking a very small amount of current.

The electric motor presents very great advantages over the steam engine or the oil engine. No time is lost in preparation, no man is needed to fire the boiler, to start the engine, or to stand by the lamp while the oil engine is running, and the motor can be easily stopped should an accident take place. The only precaution desirable is to run the motor for half an hour at a time during wet weather to keep the insulation dry and in good condition.

In regard to ploughing, Mr. Low has not tried this, and has some doubts about the feasibility. He would not recommend the battery-driven wagon to pull the plough, and the cost of erection and maintenance of conductors at every fence on a farm would be great for a seasonal purpose, and very ugly.

The *Journal* of the Board of Agriculture for June, gives costs of ploughing with a Wyles petrol-driven plough, which shew wonderfully good results.

He has had good results in converting timber, using a 15 h.p. motor to drive a band saw. The saws are 2 inches to 2½ inches wide, and he has been able to cut up an oak log 30 inches by 34 inches with this plant. It was not done quickly, but was possible. The usual type of timber dealt with is old Scotch fir, which is sawn into battens and boards. The band saw makes excellent

work with less waste than the circular saw, and required less power. The same motor is also arranged to drive a stone-breaker, to prepare material for repairing the roads.

For water pumping which has to be done slowly so as not to exhaust the well, he finds a 1 h.p. motor large enough to pump against a head of from 30 to 55 feet.

Besides lighting, Mr. Low uses electricity for heating by means of radiators ; these can be used at night when there is no other load on the turbine, and he has found it most convenient to have fans for ventilating purposes.

A 1 h.p. motor is capable of driving a mangle, thereby relieving the laundrymaid of an exceedingly irksome job, and allows her to fold whilst the mangle is working. This saved a day's work in the week.

He also has a cold storage plant driven by a $2\frac{1}{2}$ h.p. motor, which is sufficient to work a CO_2 compressor, pump the cooling water, and circulate the brine. Five hours' work, twice a week, keeps the cooling chambers at a temperature between 34° F. and 40° F., and makes 1 cwt. of ice, 56 lbs. at a time. The ice has begun to form at the end of five hours run in the moulds, which remains in the brine tank until the following morning, by that time a solid block of ice is formed. The brine is cooled to 27° F.

With a supply of electricity which can be counted on, cooking presents very great possibilities, but there must be no failure in the supply.

Mr. Low has experimented with electro-culture for six years, and while he is satisfied that it increases the crop under certain conditions, he has not been able to show the cost. The reasons are : First, that he has not yet learned how much stimulating plants need or the conditions under which that stimulation can be most profitably applied ; and, second, the very great difficulty in carrying out the tests. Apart from the uncertainty of all agricultural experiments due to the variation in the soil of the field, and the necessity of repeating them at will, there is the trouble that the electricity discharged by the

overhead network is carried so far by the wind, and that there is no way of combing out the particles of electrified air so as to prevent them straying on to the control plots.

This effect was shewn by Mr. Jorgensen, a Danish electrician, who worked for some years under Professor Priestley, of Leeds University.

With a wind of only 5 m.p.h., Mr. Low has observed, by means of an Enner electroscope, a potential difference of 500 volts per metre of height at 360 yards to leeward of his overhead network. He uses a sodium candle, mounted on an ebonite rod one metre long, to collect the electricity in the air at the place where the examination is being made.

This electroscope discharges itself when the potential difference reaches 500 volts between the candle and the ground. Under the network one may get 140 discharges per minute ; 10 yards to the windward side there is no appreciable increase over the electrical condition of the atmosphere, while down wind it may be carried for a long distance, depending on the velocity of the wind.

To endeavour to intercept a part of this drifting electricity, he erected a wire netting screen 16 feet high, made of $\frac{1}{2}$-inch mesh wire netting. This extended 10 yards beyond the overhead network at either end, and was placed parallel to it between the trial and control plots, but it is of little use when the wind is blowing directly on to the control. It may help when the wind is parallel, or nearly parallel, to the screen.

The most satisfactory result he obtained was in 1914, with hay. A difference of 20 per cent. was observed on two different pairs of plots ; but that year was an exceptional one, because during the time the excitation was applied the wind was continuously southerly, and blew from the control to the trial plots.

He has heard of, but has not had a chance to see, the experiments on eggs and chickens, and he distrusts the story of the effect on fattening sheep ; it is not what an animal eats, but what it digests, that fattens it, and no graminivorous animal spends its whole time eating ; a great part of every day it rests,

and chews the cud. Most animals depend on their noses as much as their eyes to find their food, so the sheep could feed in the dark if they felt so inclined.

He feels sure Mr. Kerr's paper will have a stimulating effect on supply companies, and he suggests to them the advisability of laying their schemes before the agricultural and rural community. The farmer will look narrowly into costs, but once a start is made, and the advantages recognised, the uses of electricity should spread.

Mr. B. A. Tapp (*communicated*) says the paper is the only one during the twenty years' existence of the Municipal Electrical Association dealing with the important subject of the agricultural uses of electricity, and its interest is considerably enhanced by the fact that the author has had several years' personal experience of his subject, and is therefore the better able to appreciate its imminent possibilities. Although we, in this country, have had comparatively little experience in this matter as compared with continental and American engineers, yet we can definitely say that the British farmer welcomes electrical methods, and is willing to pay for the supply at rates which make him a very profitable customer of the supply authority; moreover, he is an enterprising consumer whose potentialities are only now being tested, and it is fair to assume that initial farm revenues will be doubled in the course of a few years, if agricultural electricity supply is systematically exploited by our engineers. It should be realised, however, that owing to the present shortage of agricultural labour and the efforts being made by the oil-engine makers to meet the power requirements of farmers at the present time, any attempt to exploit agricultural electricity supply on a general scale (in areas which are reasonably accessible to existing electricity suppliers) should have immediate consideration and should also be properly organised in order to be effective.

It would be advisable for those central station engineers, both municipal and company, who are interested in the matter, to arrive at some acceptable standard method of carrying out farm installations and farm services, and of formulating suitable tariffs. The special features of electric light and power which appeal strongly to the agriculturist should be systematically advertised, and an attempt made to interest the electrical and

agricultural machinery people so that their co-operation would be available for experimental or demonstration installations in the neighbourhood of country towns and at agricultural shows, which have been lamentably neglected by the electrical people in the past.

If our agricultural machinery firms could be convinced that the electric supply authorities are really in earnest, they would no doubt turn their attention to the design of a suitable ploughing equipment, as in the case of certain German firms who have standardised such apparatus. Our electrical firms can also, doubtless, supply a simpler, lighter and less costly form of overhead transmission for use on farm lands.

Although the individual electrical incubator only consumes roughly one unit per chick for hatching and rearing, for five weeks, it is obvious that an incubator establishment where from 10,000 to 20,000 chickens are hatched during the first six months of the year, would be a desirable consumer, especially when ordinary lighting and small motor uses are included in the load.

The question of electrical incubators should be considered in conjunction with our annual importation in normal times of 1,250,000,000 eggs valued at £10,000,000; if the use of electrical methods of chicken production will enable us to produce anything like the above quantity of eggs in this country, in addition to those already produced here, it is evident that the incubator load as a whole will be well worth catering for.

Mr. Tapp mentions that he has already drawn attention to the national aspect of this question in the pages of the *Electrical Review*, and that the opinions there expressed still hold good. Agriculture is our greatest industry, and the present war has shown its shortcomings which can to some extent be removed by the adoption of labour-saving methods, towards which nothing will contribute so much as the general adoption of electric light and power in our farms and villages.

Mr. W. T. Kerr, in his reply (*communicated*), says, he should like to add one more to the many benefits so ably stated by Councillor Langford on the advantages to the farmer. It is one that has been put forward since the discussion by Mr. Roberts,

the Divisional Traffic Superintendent of the Great Western Railway Company, who was very interested in the suggestions made, as they would be the means of helping the railway companies out of a difficulty that up to the present no means had been found to overcome. The question of acceleration of running traffic in early mornings necessitated earlier milk trains, a proposal which met with strong opposition from agricultural districts, as the farmers were unable to get the milk conveyed any earlier to the stations owing to the dislike of the farm hands to starting milking operations before the usual hour.

The general adoption of electrically driven milking machinery would enable milking to be carried out at the same hour all the year round, no matter how many cows were kept, and thus ease the railway companies' early morning traffic problem.

This is a point worth noting and putting to a railway company when a Supply Authority is endeavouring to get wayleaves.

The point raised by Mr. W. B. Woodhouse has been realised by farmers in the Hereford district, in fact one farmer had so high an insurance premium to pay that on conversion to electricity the reduction on one year's assessment defrayed the cost of the electrical equipment.

The question asked by Mr. W. Burr has not yet been settled, but up to the present time no detrimental effects whatever have been observed. Research work to determine with the greatest accuracy, what is the exact physiological operation that takes place under electrical stimulation, is now being carried out. The present conclusion arrived at is that under the influence of electric discharges the sap necessary to plant growth is enabled to flow more regularly.

In reply to Mr. William Low of Marykirk they have as yet had no occasion to go through woods in the author's district, but where they come across trees of any size they obtain permission to lop any branches that were likely to touch the wire. It was found from experience that stranded aluminium wire was much preferable to copper. It was so much easier to handle that the overhead gang always asked for it in preference.

In regard to other farming operations Mr. Low and Councillor Langford are in agreement as to the many great advantages of electricity.

With regards to the ploughing, Mr. Low raises the same objection as Mr. Ayton, and possibly they are right, but this is so important an operation and one requiring so much electric power every year, that with harrowing and scuffling it would mean a fairly constant load all the year round. A great deal more cultivation would be done if the horse difficulty could be got over, and a reliable electrical substitute would mean much better cultivation in the future.

The author is proposing to carry out some experiments in this direction, and no doubt, with the aid of agricultural machinery engineers, a good many of what now look like unsurmountable obstacles may be overcome.

The author desires to acknowledge the help he has received from Mr. Benjamin Tapp in preparing the paper, and to thank Miss E. C. Dudgeon, of Lincluden House, for a great deal of interesting information on electro-culture, and to acknowledge the kindness of the Editors of the *Electrical Review* and *Manchester Guardian* for the loan of certain blocks illustrating the paper.

Incorporated Municipal Electrical Association.

TWENTY-FIRST ANNUAL REPORT OF THE COUNCIL,

From June, 1915, to June, 1916.

Submitted to the Annual General Meeting in London, on Friday, June 23rd, 1916.)

The membership of the Association now stands at 377, made up as follows :

Committees (Members)	168
Chief Electrical Engineers (Members)	172
Honorary Members	6
Chief Assistants (Associate Members)	4
Assistants (Associates)	27
	377

After allowing for deaths, resignations, removals, transfers and lapses due to members leaving Municipal employ, there is no change in the total membership.

Since the publication of the last Annual Report, the Council have held eight meetings, all in London. There have been also a number of meetings of Standing and Special Committees and Sub-Committees appointed to deal with specific matters. These Committees have met and reported to the Council periodically on the matters referred to them.

By the courtesy of the Council of the Institution of Electrical Engineers, the Council and Committee meetings in London have been held at the Institution's headquarters.

The attendances of members of Council are set out in the following schedule :

	1915.			1916.						
	June 16th, London.	June 18th, London.	Nov. 19th, London.	Jan. 14th, London.	Feb. 18th, London.	Mar. 17th, London.	April 14th, London.	May 12th, London.	Maximum possible.	Actual.
Ayton, F., Ipswich	×	—	Time expired.							
Barge, Councillor H. R., Poplar			×	×	×	×	×	×	6	6
Beecham, Alderman Sir J., St. Helens			—	×	—	×	×	×	6	4
Beauchamp, J. W., West Ham	×	—	×	×	×	×	×	×	8	7
Blackman, A. S., Sunderland	×	×	×	×	×	×	×	×	8	8
Britton, S. E., Chester			×	×	—	×	×	×	6	5
Chattock, R. A., Birmingham	×	×	—	×	—	×	×	×	8	6
Christie, J., Brighton	×	×	Time expired.							
Cramb, A. C., Croydon	×	×	×	×	×	×	×	×	8	8
*Crowther, Councillor, Sheffield	×	×	—	×	—	×	—	—	8	4
Edgcome, J. E., Kingston-upon-Thames	—	—	×	×	×	×	—	×	8	5
Ellaway, Alderman, Birmingham	×	×	—	—	×	×	×	×	8	6
Fedden, S. E., Sheffield	×	×	×	×	×	×	×	×	8	8
Gibson, Councillor, Wolverhampton	×	×	Time expired.							
Lackie, W. W., Glasgow	—	×	×	—	×	—	—	×	6	4
Long, F. M., Norwich	—	—	×	×	×	—	×	×	8	5
Miller, Alderman, Croydon			—	—	—	—	×	×	6	2
Nairn, Bailie, Dundee	—	—	Time expired.							
Pearce, S. L., Manchester			×	×	×	—	—	×	6	4
Pearson, Alderman G., Bristol	×	×	—	×	×	—	—	—	8	4
Proctor, H. Faraday, Bristol	×	×	—	×	×	×	×	×	8	7
†Richardson, H., Dundee	—	—	—	—	—	—	—	—	8	—
Roles, T., Bradford	×	×	×	×	×	×	×	×	8	8
Seabrook, A. H., London	×	—	—	—	—	—	—	—	8	1
Sinclair, Councillor, Swansea	×	×	Time expired.							
Smith, Alderman, J.P., Barrow	—	×	—	×	—	—	—	—	8	2
Smith, Bailie, W. B., Glasgow	×	×	×	×	—	—	—	×	8	5
†Vignoles, W. A., Grimsby	—	—	—	—	—	—	—	—	8	—
Watson, S. J., Bury	×	×	Time expired.							
Wilkinson, G., Harrogate	×	—	×	×	×	—	×	×	8	6
Wyld, W., Hampstead	×	—	×	×	×	×	×	×	8	7

* Deceased. † On Active Service.

Model General Conditions of Contract.—The British Electrical and Allied Manufacturers Association have expressed the hope that the Incorporated Municipal Electrical Association would now recognise the Institution of Electrical Engineers' conditions as standard. The Council have, however, been unable to take any further steps in the matter pending the receipt of the Report of the Association of Municipal Corporations.

I.M.E.A. Bill.—At the suggestion of the British Electrical and Allied Manufacturers Association, joint meetings of representatives of the Incorporated Municipal Electrical Association, the British Electrical and Allied Manufacturers Association, and the Electrical Contractors Association have been held, at which it was believed that a completed settlement agreeable to all parties had been arrived at.

After reference to the full Councils of the respective Associations, however, the Electrical Contractors Association finally declined to continue negotiations and decided to oppose the Bill so long as powers to sell are retained therein.

Engineering Standards Committee.—At the last Annual Meeting an appeal was made to representatives of the Committees present to contribute more liberally to the funds of the Engineering Standards Committee, and shortly afterwards the Association issued an appeal to its members, the result of which was a substantial addition to the subscriptions from Municipalities to that Committee. The Association also renewed its donation of £21.

The Association is represented on the following sectional Committees, Sub-Committees, and Panels of the Engineering Standards Committee :

Sectional Committee and B.N.C. Standardisation of Rules for Electrical Machinery	R. A. Chattock and A. H. Seabrook.
	J. Christie.
Electric Lamps	S. E. Fedden and G. Wilkinson.

Electric Power Cables	A. C. Cramb and W. Wyld.
Electrical Accessories	A. C. Cramb and A. H. Seabrook.
Prime Movers	F. M. Long and H. Faraday Proctor.
Panels of the Sub-Committee on Electrical Accessories :—	
(*a*) Plugs	A. C. Cramb and A. H. Seabrook.
(*b*) Switches	A. C. Cramb.
(*c*) Fuses	W. Wyld.
(*d*) Heating and Cooking	A. H. Seabrook.
(*e*) Carbon brushes, control gear and electric vehicle accessories	F. Ayton.
(*i*) Meter Panel	J. W. Beauchamp.

Eastbourne Accident and the Board of Trade.—The Council have had under consideration the Report of the Electrical Adviser to the Board of Trade, on the subject of the fatal accident which occurred on December 26th last, arising out of the collision of a motor car with a switch pillar.

At the request of the Eastbourne Electricity Committee, the Council received Mr. Fovargue, the Town Clerk, and Mr. Brydges, the Electrical Engineer, who, after laying before the Council certain information with regard to the matter, expressed a desire that the Council should approach the Board of Trade with a view to getting the recommendations contained in the above-mentioned Report modified.

The question is still engaging the attention of the Council.

Coal Supplies.—On the invitation of the Institution of Electrical Engineers the Association appointed a representative to attend a National Conference of representatives of the Gas and Electrical Industries for the purpose of considering the question of Coal Supplies, at the Institution Building on May 6th, 1915. Mr. Chattock represented the Association at this Conference, which was attended by a large number of engineers and Committee representatives of Municipal Electricity Supply Undertakings from all parts of the country.

As a result of the deliberation a deputation of 34 representatives was appointed to present the case to Members of Parliament, asking for their assistance in urging the Government to give effect to the recommendations passed at the meeting, calling for increased output, railway transit facilities, and proper regard to the requirements of public utility undertakings dependent upon their supplies on sea-borne coal, when requisitioning coal steamers. The following members of the Association were included in the deputation : Messrs. A. C. Cramb, R. A. Chattock, S. L. Pearce, A. H. Seabrook, and Bailie Smith. Two Honorary Members of the Association, namely, Sir John Snell and Mr. W. A. Chamen, representing the interests of the Institution of Electrical Engineers and the Incorporated Association of Electric Power Companies respectively, were also included in the deputation.

At a further meeting of the members of the deputation a Sub-Committee was appointed on which the Association was represented by Mr. R. A. Chattock.

Bailie Smith, a member of the I.M.E.A. Council, took a prominent part in the negotiations with the Coal Export Committee, and subsequently he was successful in getting an amendment made to the Price of Coal (Limitation) Bill, giving power to public utility undertakings to have the Bill made retrospective to include already placed contracts.

Bailie Smith received the thanks of the Council for his valuable service, on which occasion he expressed the view that the amending clause would have been more satisfactory if representatives of other large cities had also taken the matter up.

The whole question of coal supply as affecting members of the Association was referred to a Sub-Committee with instructions to make recommendations and to assist members in any difficulty, with advice as to proper procedure.

In March 1916, a summary of the report and recommendations of the Sub-Committee, which had been adopted by the Council, was communicated to the members. This was to the effect :

(*a*) That a stated case was being considered by the Board of Trade on the question of price under the Price of Coal (Limitation) Act, 1915, but no decision had then been received.

(*b*) That the response to the circular letter sent out by the Secretary with regard to the supply of coal, showed that while there had been, in many cases, serious difficulty in getting the necessary supply, there was a serious shortage in connection with a few undertakings only.

(*c*) That the Board of Trade had, on February 7th, 1916, instituted Committees on Coal and Coke Supplies in eleven districts throughout the country as follows :

(1) Scotland.
(2) Northumberland.
(3) Durham.
(4) Cumberland.
(5) Lancashire, Cheshire and North Wales.
(6) West Yorkshire.
(7) South Yorkshire.
(8) Nottingham, Derby and Leicester.
(9) Staffordshire, Warwickshire and Shropshire.
(10) South Wales.
(11) Somersetshire, Forest of Dean and Bristol Coalfield.

(*d*) That the business of these Committees is to see that the resources of their respective districts are used to the best advantage, and that the requirements of important industries are fully met. A parent Committee was formed by the Right Hon. Walter Runciman, President of the Board of Trade, to consider all questions relating to the distribution of coal and coke that may be referred to it from time to time by the Board of Trade, or submitted by the Coal and Coke Committee of any district.

(*e*) That the Committee recommended that Local Authorities should approach their Local Committee on the supply of coal and coke.

(*f*) That the Association had approached the Board of Trade, urging them to restrict the exportation of small coal and to limit exportation to large bunker coal, and the Board of Trade state that they were bringing the communication before the District Committees on the Supply of Coal and Coke.

Since the District Committees have got to work it has become evident that they have very little power to obtain coal for Public Utility Undertakings, and this appears to be due to the fact that there are no legal powers for this

conferred upon the Board of Trade. Steps have therefore been taken to urge upon the Government the desirability of giving the Board of Trade powers to distribute coal where it is required, and to organise local coal for local use as far as possible, and so relieve congestion on the railways. It was also urged that more steamers should be provided to bring coal down from the North to the South of England.

The Sub-Committee is continuing its work and dealing with enquiries from members.

The Council.—In accordance with the power vested in them, the Council elected Ald. Miller of Croydon, a member of their body for the current year, and appointed Councillor S. Evans of Sheffield to fill a vacancy caused by the death of the late Councillor Crowther of Sheffield. The Council desire to place on record their appreciation of the services which Councillor Crowther rendered to them and to the Association.

The Council have had under consideration a communication from Mr. Purse (Member) of Carlisle, making observations on the constitution of the Council, and some suggestions having for their object more particularly a definite representation of the smaller undertakings on the Council, and the substitution of a postal ballot for the present procedure whereby the ballot is restricted to those members attending the Annual Meeting.

On the invitation of the Council a deputation representing some of the smaller Undertakings attended a meeting and placed their views personally before the Council.

The Council are of opinion that it would be unfortunate to draw any distinctions between members as representing the large or small undertakings or otherwise, and believe that satisfactory representation is gained under the existing Articles of Association. The opinion of Members will be taken at the Annual Meeting upon the question of the suggested postal ballot.

Institution of Electrical Engineers' Wiring Rules.—The Institution Wiring Rules Committee, on which the Association has two representatives, have again revised the Rules and invited the Council of the Association to give their adhesion thereto. This the Council have done, but with the recommendation that the Rules should be re-arranged, so as to distinguish Regulations from Recommendations. At the same time the Council made suggestions or amendments for further revision.

British Trade after the War.—The Council have had before them the Report of the Sub-Committee of the Advisory Committee of the Board of Trade on Commercial Intelligence, with respect to measures for securing the position, after the war, of certain branches of British industry, and after having given the Report careful consideration unanimously passed the following resolution :

> " That this Council, while being anxious in every way to encourage British Trade and the purchase of home manufactures, and being prepared heartily to support measures taken to this end by legislation or otherwise, view with deep concern Recommendation 6 (*b*) of the Sub-Committee of the Advisory Committee of the Board of Trade to the effect that :
>
> > " ' All Government Departments, Local Authorities and Statutory Bodies entrusted with the control of monies raised by taxes or rates, should be under legal obligation to purchase, so far as possible, only goods produced within the British Empire.'
>
> " The Council is strongly of the opinion that in the event of this Recommendation being adopted, the interests of Municipal Electrical Undertakings and their consumers—which latter embrace some of the largest manufacturing concerns in the country—will be seriously jeopardised, and that Municipalities should in no way be subjected to any restrictions with regard to the purchase of plant and materials other than those imposed on private concerns."

Copies of this resolution were sent to the Institution of Electrical Engineers, the Association of Municipal Corporations and other interested bodies.

Honorary Treasurer's Report.—The chief features of the Accounts are a reduction in the cost of postages, printing and stationery, and in general expenses. The income from subscriptions remains stationary, and there is a decrease in the income from sales and advertisements derived from the Proceedings. The net result is a surplus for the year of £77, as against £62 last year. The Balance Sheet shows a slight decrease in the liabilities and a surplus of assets over liabilities of £926.

In regard to the Parliamentary expenses, applications are being made to those Municipalities who have promised financial support with a view to the amount already expended being refunded to the Association.

It is submitted that considering the prevailing conditions the financial position may be considered very satisfactory.

Development Committee.—Owing to circumstances caused by the war, the Development Committee have for the time being suspended their activities.

Electric Vehicle Committee.—The report of this Committee accompanies the Council's Report for the information of the Association.

National Association of Local Government Officers—The Association was represented at the Annual General Meeting of this body by Mr. Edgcome, Past President, Hon. Treasurer, and Mr. Wyld. The question of the Superannuation Bill upon which the National Association of Local Government Officers were in communication with the Local Government Board, was discussed, but little progress can be made unless the larger municipalities support the proposal. They now have the support of all interested representative bodies except the Urban District Councils Association, who, while in favour of the principle, were not giving it active support.

The National Association of Local Government Officers now issue an official journal which can be supplied free of charge to such members of the Association as do not receive it from another source, on application to the Secretary of the I.M.E. Association.

Financial Organisation.—As a result of the Council having received a number of communications from Engineer Members intimating that difficulties were being experienced by them in efficiently managing the undertakings for which they are responsible, by reason of the systems of financial control adopted by the Local Authorities owning such undertakings, it was decided that the matter was of such importance as to warrant the appointment of a Special Sub-Committee to consider the whole question and to report thereon.

At the first meeting of the Sub-Committee held during the year under review the members were informed that Mr. S. J. Watson, who had been appointed Honorary Secretary, would be unable to continue to carry out the duties of the office owing to his being no longer a member of the Council. Mr. W. Wyld was thereupon requested to assume the duties of Honorary Secretary, and consented to do so.

The Sub-Committee, after deliberating upon certain evidence which was put before them, came to the conclusion that the difficulties experienced were not peculiar to electricity supply undertakings, but were common to all municipally-owned trading departments, and that the matter could better be dealt with by a Joint Committee composed of members of various interests concerned. To this end the co-operation of the Municipal Tramways Association (Incorporated), the Municipal Waterworks Association, and the Institution of Gas Engineers was invited, with the result that these bodies have appointed representatives to serve on a Joint Committee, and meetings of the Committee so formed are being held.

A request has been forwarded to all Engineer Members of the Incorporated Municipal Electrical Association to submit to the Honorary Secretary of the Sub-Committee particulars of troubles which are being experienced by them in connection with the financial control of the undertakings with which they are connected. A considerable number of replies have been received, and will be considered by the Joint Committee at an early date.

The matter being one of equal importance to the Chairmen and Members of Electricity Committees as to the Engineer Members, the Council have recently strengthened the Sub-Committee by the addition of three "Chairmen" members.

The somewhat brief statements on matters of importance such as the I.M.E.A. Bill, etc., convey little idea of the amount of work done by the members of the various Committees and Sub-Committees, who have been called upon to give a great deal of time to the consideration of questions referred to them. The Council and the Association are particularly indebted to the Hon. Secretary, Mr. H. Faraday Proctor, for the manner in which he discharges the duties devolving upon him.

INCORPORATED MUNICIPAL

INCOME and EXPENDITURE ACCOUNT

The Bold Figures are for the twelve

1915. £	s.	d.	EXPENDITURE.	£	s.	d.	1916. £	s.	d.
			To General Expenses—						
10	11	7	Reporting and Clerical Assistance	6	6	0			
1	1	3	Bank Charges	0	14	6			
4	4	0	Audit Fee	4	4	0			
72	18	10	Sundry Expenses	6	8	6			
88	15	8					17	13	0
–	–	–	,, Legal Expenses				4	9	0
33	13	9	,, Postages				25	8	1
225	18	0	,, Printing and Stationery				170	18	6
150	0	0	,, Secretary's Salary				150	0	0
609	15	11	,, Convention Expenses				–	–	–
24	10	0	,, Commission				19	15	3
			,, Donations—						
–	–	–	I.E.E. Ben. Fund	10	10	0			
–	–	–	N.A.L.G.O.	3	3	0			
–	–	–	Eng. Standards Committee ...	21	0	0			
							34	13	0
1	11	2	,, Electric Vehicle Committee Expenses ...				–	–	–
–	–	–	,, Bad Debts				6	1	0
62	7	6	,, Surplus				77	4	1
£1,196	12	0					£506	1	11

BALANCE SHEET as

1915. £	s.	d.	LIABILITIES.	£	s.	d.	1916. £	s.	d.
19	19	0	To Subscriptions paid in advance				22	1	0
17	1	6	,, Sundry Creditors				12	18	1
			,, Surplus—						
786	8	5	Balance, April 1st, 1915	848	15	11			
62	7	6	Plus Surplus, for year 1915-16 ...	77	4	1			
848	15	11					926	0	0
£885	16	5					£960	19	1

Report of the Auditors, to the Members of the Incorporated Municipal

We have audited the above Balance Sheet, dated 31st March, 1916, and our opinion it is properly drawn up so as to exhibit a true and correct view of and the explanations given us, and as shown by the books of the Association.

140, Leadenhall Street, London, E.C., 8th May, 1916.

ELECTRICAL ASSOCIATION.

for the year ended 31st March, 1916.

months ended 31st March, 1915.

1915. £	s.	d.	INCOME.	£	s.	d.	1916. £	s.	d.
			By Annual Subscriptions—						
175	7	0	Committees	175	7	0			
187	3	0	Members	185	17	0			
4	4	0	Associate Members	4	4	0			
7	0	0	Associates	6	15	0			
373	14	0					372	3	0
19	9	6	„ Dividends and Interest				21	14	5
			„ "Proceedings"—						
139	9	9	Sales and Advertisements				101	14	6
663	18	9	„ Convention Receipts				–	–	–
–	–	–	„ Delegates' Fees				10	10	0
£1,196	12	0					£506	1	11

at 31st March, 1916.

1915. £	s.	d.	ASSETS.	£	s.	d.	1916. £	s.	d.
			By Sundry Debtors—						
1	1	0	Committees	1	1	0			
11	11	0	Members	23	2	0			
–	–	–	Associate Members	1	1	0			
2	0	0	Associates	3	15	0			
0	15	0	Sundry	5	5	0			
15	7	0		34	4	0			
1	6	0	Less Reserve for Bad Debts ..	6	6	0			
14	1	0					27	18	0
123	15	0	„ Parliamentary Expenses to be refunded ...				121	13	0
			„ Investment *at Cost*—						
599	5	0	£600 L.C.C. 3½ % Stock				599	5	0
100	0	0	£105 19*s.* 9*d.* 3½% War Loan Stock ...				100	0	0
			NOTE.—The present market value of these investments is £626.						
			„ Cash—						
42	18	8	At Bank				106	18	8
5	16	9	In Hand				5	4	8
£885	16	5					£960	19	1

Electrical Association.
have obtained all the information and explanations we have required. In the state of the Association's affairs, according to the best of our information

BOLTON, PITT & BREDEN, *Auditors.*
J. E. EDGCOME, *Hon. Treasurer.*

Incorporated Municipal Electrical Association.

REPORT OF THE ELECTRIC VEHICLE COMMITTEE FOR THE YEAR ENDED MARCH 31st, 1916.

The following has been the constitution of the Committee between the 1st April, 1915, and 31st March, 1916, the period covered by this Report:

Representing the Incorporated Municipal Electrical Association—

F. Ayton, Engineer and Manager, Ipswich Corporation Electric Supply and Tramways.
J. W. Beauchamp, Engineer and Manager, West Ham Corporation Electric Supply.
R. A. Chattock, City Electrical Engineer, Birmingham.
A. C. Cramb, Borough Electrical Engineer, Croydon.
J. Christie, Engineer and Manager, Brighton Corporation Electric Supply.
J. E. Edgcome, Borough Electrical Engineer, Kingston-on-Thames.
H. Faraday Procter, Engineer and General Manager, Electricity Department, City of Bristol, Hon. Sec. I.M.E. Association.
A. H. Seabrook, Manager, St. Marylebone Electric Supply, London.

Representing Commercial Motor Users' Association, Incorporated—

E. S. Shrapnell-Smith, Editor of "The Commercial Motor."

Representing Provincial Electric Supply Companies—

F. E. Gripper, Managing Director, Edmundson's Electricity Corporation, Ltd., London.

Representing Electrical Contractors' Association—
W. R. RAWLINGS, Rawlings Bros., Ltd., London.

Representing British Electrical and Allied Manufacturers' Association—
R. A. R. BOLTON, Siemens Bros. Dynamo Works Co., Ltd.
A. R. EVEREST, British Thomson-Houston Co., Ltd.
E. S. NEW, D.P. Battery Co., Ltd.
C. C. RATTEY, Pritchett & Gold and Electrical Power Storage Co., Ltd.

Representing Incorporated Association of Electric Power Companies—
J. S. HIGHFIELD, Chief Engineer, Metropolitan Electric Supply Co., London.

Representing Makers of Electric Vehicles—
E. W. CURTIS, General Vehicle Co., Ltd.
J. F. MONNOT, Arrol-Johnston, Ltd.
A. E. MEADEN, Wolseley Motors, Ltd.
P. A. MOSSAY, Ransomes, Sims & Jefferies, Ltd.

Representing Edison Accumulators, Ltd.—W. H. L. WATSON.

Representing Chelsea Electricity Supply Co., Ltd.—P. STILL.

Representing Garage Proprietors—
G. F. HEATH, Heath's Garage, Ltd., Birmingham.

Representing the Institution of Municipal and County Engineers—
A. E. COLLINS, City Engineer, Norwich.

Representing Municipal Tramways Association (Incorporated)—
A. R. FEARNLEY, General Manager, Sheffield Corporation Tramways.

Representing Tramways and Light Railways Association—
A. V. MASON, General Manager, South Metropolitan Tramways and Lighting Co.

Representing British Electrical Federation, Ltd.—R. J. HOWLEY.

MEETINGS OF THE COMMITTEE.—Five meetings of the Committee have been held, all of them in London, and the Committee is much indebted to the Institution of Electrical Engineers for their kindness in affording them facilities for meeting at the Institution.

OFFICERS OF THE COMMITTEE.—The Committee selected the following as its Officers for the year :

Chairman, R. A. Chattock.
Hon. Secretary, F. Ayton.
Hon. Treasurer, J. Christie.
Chairman of the Technical Sub-Committee, R. A. Chattock.
Acting Hon. Secretary of the Technical Sub-Committee, J. Christie.
Chairman of the Commercial Sub-Committee, A. H. Seabrook.
Hon. Editor of *The Electric Vehicle*, A. H. Seabrook.

Owing to important work which he had undertaken in connection with the supply of munitions in the London area, Mr. Seabrook found it necessary to temporarily relinquish the Hon. Editorship of the Journal and, for the time being, the work has been carried on by the Hon. Secretary as Acting Hon. Editor.

The Secretary of the Incorporated Municipal Electrical Association, Mr. McArthur Butler, attends the meetings of the Committee officially on behalf of the Association, and the Committee are indebted to him for much valuable assistance.

The work of the Committee during the period dealt with by this Report has covered the following :

Publication of "The Electric Vehicle."—*The Electric Vehicle* has been regularly brought out quarterly, and the Committee feel satisfied that it is proving a valuable means of educating the public as to the advantages of the electric vehicle for the different purposes for which it is specially recommended. Its success seems to be clearly proved by the fact that the circulation is increasing among regular subscribers who are now numbered in all parts of the world.

While a considerable number of copies of the Journal are purchased by Electric Supply Undertakings for distribution among their consumers, the whole of the copies so purchased are taken by a comparatively few progressive Supply Authorities. The Committee take this opportunity of again suggesting to those Electric Supply Undertakings that have not been distributing the Journal among the likely users of motor transport, the advantage that is likely to accrue to them by making known the electric vehicle and so obtaining another outlet for electric supply.

Lamps on Electric Vehicles.—The Committee jointly with Representatives of the Tungsten Lamp Association, have considered the question of the sizes of bulbs, and the

voltage of incandescent lamps for use on electric vehicles. The result of the joint deliberation was the issuing of a recommendation that, in view of the comparatively small consumption of electric energy by electric vehicle lamps, and the increased reliability of those made for low voltage, the standard voltage should be considered as 12 volts, the lamps to be coupled across a section of six cells in a lead-plate battery or the equivalent number in a nickel-iron-alkali battery. It was recommended that the sizes of bulbs should be those fixed by the British Engineering Standards Committee in their Report, No. 69.

Equipments for Charging Electric Vehicles.—The Committee gave considerable attention to the preparation of a pamphlet in which their recommendations as to the most suitable plant to use were embodied. This pamphlet was issued with the September Number of *The Electric Vehicle*, and further copies may be had from the Hon. Secretary, price 2d. per copy, post free.

Standardisation in Relation to Lead-Acid Accumulators.—It appeared desirable to the Committee that some standardisation should be arrived at in regard to the overall sizes of cells so that vehicle makers might standardise upon certain sizes of battery box. At the suggestion of the Committee, and through their representatives, the matter was gone into by the Accumulator Makers' Section of the British Electrical and Allied Manufacturers' Association, with the result that the Accumulator Makers have agreed to the following as the maximum overall sizes. These sizes will be known as "E.V.C." Standards: For all sizes the maximum width of the cell shall be $6\frac{5}{16}$ ins. (163 mm.) and the maximum overall height, including connector, $14\frac{7}{8}$ ins. (378 mm.). The maximum length of the smallest size, *i.e.*, that with seven plates, shall be $2\frac{7}{16}$ ins. (62 mm.) with the addition of $\frac{5}{8}$ in. (16 mm.) for each pair of plates above seven plates. An exception is in the case of the Chloride Accumulator Company's "Ironclad-Exide" type of cell in connection with which the length of the seven-plate size

is $2\frac{3}{4}$ ins. (70 mm.) with the addition of $\frac{3}{4}$ in. (19 mm.) for each pair of plates above seven plates.

A Standard rating for lead acid electric vehicle cells known as " E.V.C." Standard Rating has also been agreed to and is as follows : " E.V.C." Standard Rating shall be the capacity in ampere-hours obtained by a continuous discharge at a uniform rate for a period of five hours until the voltage of the cell falls to 1·7. Example : If a battery is specified to have an " E.V.C." Standard Rating of 180 ampere-hours, it means that the battery will give this capacity when discharged at a continuous rate of 36 amperes for a period of five hours, at the end of which time the voltage per cell shall not have fallen below 1·7 volts.

It is desirable to add that other points that have been standardised in relation to lead acid accumulators, some of them being in the Committee's previous Report, are as follows :

" E.V.C." Standard Plates.—Height, $8\frac{5}{8}$ ins. (219 mm.) ; width, $5\frac{3}{4}$ ins. (146 mm.) ; lug centres, $4\frac{3}{8}$ ins. (111 mm.).

" E.V.C." Standard Inspection Plug.—Shall be that which will fit a hole in the cover of the cell, 1 in. (25·4 mm.) in diameter.

" E.V.C." Standard Charging Voltage.—Shall be that which is suitable for charging forty-four lead-acid cells, *i.e.*, 85 to 120 volts. This voltage is also suitable for charging sixty cells of the nickel-iron-alkali type.

Standard Charging Plug and Receptacle.—This design, so far as the dimensions of the contacts are concerned, has now been adopted as a standard by the British Engineering Standards Committee and the Specification

of same has been published and can be obtained from the Secretary of that Committee, 28, Victoria Street, Westminster, S.W.

The Committee has been in communication with representative Electrical Engineers in our Colonies with a view to the British Electric Vehicle Standards being adopted throughout the British Empire.

Tyre and Road Wear Research Committee of the Motor Manufacturers and Traders' Society.—The Committee received an invitation during the year to elect a representative to sit on this Committee and the invitation was accepted. The Committee place on record their appreciation of the courtesy of the Society in inviting their co-operation in this important work.

Financial Support.—The Committee are again deeply indebted to Municipalities, Electric Supply Companies, Manufacturing Firms and others for financial assistance given during this year. The donors and the amounts received are set forth in the accompanying list.

LIST OF SUBSCRIPTIONS RECEIVED UP TO 31ST MARCH, 1916.

	£	s.	d.
Miscellaneous :			
British Electrical and Allied Manufacturers' Association	25	0	0
Commercial Motor Users' Association	5	5	0
Wolseley Motors, Ltd.	5	5	0
British Electrical Federation Ltd.	5	5	0
Ransomes, Sims & Jefferies, Ltd.	5	0	0
Electrical Press Ltd.	3	3	0
Siemens Bros. Dynamo Works, Ltd.	3	3	0
Corporations :			
Glasgow	3	3	0
Croydon	3	3	0
Manchester	3	3	0
Dundee	3	3	0
Birkenhead	3	3	0
Bradford	3	3	0
Sheffield	3	3	0

	£	s.	d.
Birmingham	3	3	0
Halifax	3	3	0
Barrow-in-Furness, for 1914-15	2	2	0
,, ,, ,, ,, 1915-16	2	2	0
Colchester	2	2	0
Bristol	2	2	0
Middlesbrough	2	2	0
Grimsby	2	2	0
Brighton	2	2	0
Dewsbury	2	2	0
Eccles	2	2	0
Chester	2	2	0
Stoke-on-Trent	2	2	0
South Shields	2	2	0
Eastbourne	2	2	0
Nuneaton	1	1	0
Norwich	1	1	0
Loughborough	1	1	0
Worthing	1	1	0
Companies :			
Newcastle-on-Tyne Electric Supply Co., Ltd.	10	0	0
Chelsea Electricity Supply Co., 1914-15,	5	5	0
,, ,, ,, ,, 1915-16	5	5	0
,, ,, ,, ,, 1916-17	5	5	0
County of London Electric Supply Co.	2	2	0
Bournemouth and Poole Electric Supply Co., Ltd.	1	1	0
Urban District Councils :			
St. Annes-on-Sea	1	1	0
Total	£141	17	0

The Electric Vehicle Association of America.—This Association has now ceased to exist as a separate body. Its members have been absorbed into the National Electric Light Association of America which has a membership of about 14,000. The N.E.L.A. has formed an Electric Vehicle Section and this Committee is affiliated with that Section through the membership of the Secretary. The Committee desire to place on record their indebtedness for the amount of useful information which has been so courteously supplied to it during the past year by the energetic Secretary of the Electric Vehicle Association of America, Mr. A. Jackson Marshall.

Accounts.—Attached to this Report will be found the audited statement of accounts and balance sheet.

It will be noticed that during the past year the following additional bodies have become represented on the Committee :

A.—Garage Proprietors.
B.—Institution of Municipal and County Engineers.
C.—Municipal Tramways Association.
D.—Light Railways and Tramways Association.
E.—British Electrical Federation Ltd.

It is satisfactory to note that many new vehicles have been put into commission during the year so that, at the present time, the estimate of vehicles in use in the United Kingdom is in the neighbourhood of about 680.

This number includes forty-eight electric warehouse or works trucks, the use of which is likely to considerably extend in the near future. It is noteworthy that thirty-three municipalities operate between them, or have on order seventy-eight vehicles. The total number of vehicles quoted above shows an increase during the twelve months of 197 vehicles.

The Committee take the opportunity of expressing their thanks to the Honorary Secretary, Mr. F. Ayton, for the very able and efficient manner in which he has handled the work of the Committee. They realise that Mr. Ayton has given up a very large amount of his time in furthering their interests, and they wish to record their appreciation of this and of the great and untiring assistance that he has given to them.

INCORPORATED MUNICIPAL

THE ELECTRIC

INCOME AND EXPENDITURE ACCOUNT

The bold figures are for the twelve

1915. £	s.	d.	EXPENDITURE.	£	s.	d.	1916. £	s.	d.
47	6	2	To Postages and Telegrams				55	11	8
31	1	7	,, Printing and Stationery				50	3	8
12	3	0	,, Sundry Expenses				21	8	4
21	9	5	,, Clerical Expenses				18	3	0
–	–	–	,, Audit Fee				5	5	0
167	4	11	,, Printing Mail Cards and Journal (Nos. 3, 4, 5 and 6)...	260	16	6			
30	0	0	,, *Less* Stock of Publicity Mail Cards, value taken at half Sale Price ...	–	–	–			
							260	16	6
137	4	11							
–	–	–	,, Bad Debts				12	13	0
249	5	1					424	1	2
95	5	3	,, Surplus				45	17	2
£344	10	4					£469	18	4

BALANCE

1915. £	s.	d.	LIABILITIES.	£	s.	d.	1916. £	s.	d.
16	16	8	To Sundry Creditors				1	16	11
95	5	3	,, Surplus—						
			Balance, April 1st, 1915	95	5	3			
			Surplus for year 1915–16	45	17	2			
							141	2	5
£112	1	11					£142	19	4

NOTE.—There is a contingent liability to Electrical Press, Ltd., for Journal Advertisements and Sales, amounting to £143 9*s.* 3*d.*

REPORT OF THE AUDITORS TO THE MEMBERS

We have audited the above Balance Sheet, dated 31st March, 1916, and our opinion it is properly drawn up so as to exhibit a true and correct view tion and the explanations given us, and as shown by the books of the

140, Leadenhall Street, London, E.C.
30th May, 1916.

ELECTRICAL ASSOCIATION.

VEHICLE COMMITTEE

for the year ended 31st March, 1916.

months ended 31st March, 1915.

1915. £ s. d.	INCOME.	£ s. d.	1916 £ s. d.
	By Subscriptions—		
116 11 0	Municipalities	78 5 0	
52 2 0	Other Associations	35 10 0	
30 10 0	Companies and Private Individuals ...	15 10 0	
			129 5 0
199 3 0			
145 7 4	,, Journals (Nos. 3, 4, 5 and 6) and Mail Cards— Sales and Advertisements		340 13 4
£344 10 4			£469 18 4

SHEET.

1915. £ s. d.	ASSETS.	£ s. d.	1916. £ s. d.
	By Sundry Debtors—		
12 12 0	Municipalities	- - -	
9 15 5	Electrical Press, Ltd.	8 0 3	
			8 0 3
22 7 5			
1 8 7	,, Sample Apparatus	... ...	1 8 7
7 10 0	,, Furniture	... ...	7 10 0
30 0 0	,, Stock of Publicity Mail Cards, value taken at half Sale Price in 1915	.. ..	- - -
	,, Cash—	£ s. d.	
46 11 5	At Bank	121 18 1	
4 4 6	In hands of Secretary	4 2 5	
			126 0 6
50 15 11			
£112 1 11			£142 19 4

On behalf of the Committee,

F. AYTON, *Hon. Secretary.*

J. CHRISTIE, *Hon. Treasurer.*

OF THE ELECTRIC VEHICLE COMMITTEE.

have obtained all the information and explanations we have required. In of the state of the Committee's affairs according to the best of our informa- Committee.

BOLTON, PITT & BREDEN, *Auditors.*

Annual General Meeting.

FRIDAY, JUNE 23rd, 1916.

The Annual General Meeting was held at the Institution of Electrical Engineers at 10 a.m.

Council's Report.

The Annual Report of the Council for the past year having been taken as read, a discussion took place upon the various paragraphs.

Model General Conditions.—**Mr. R. A. Chattock** (Birmingham) said that these Conditions had now been before the Association for about three years. At the special meeting that was called about two years ago, the Council were instructed to lay the matter before the Association of Municipal Corporations and they were not to do anything until they had received a report from that Association. A meeting had been held with the Association of Municipal Corporations, and that body promised to consider and report upon what were then known as the "Four B.E.A.M.A. Clauses." Since then, the Council of the I.M.E.A. had been pressing for a decision by the Association of Municipal Corporations, but had neither heard anything nor could they get anything definite from them. In the circumstances the matter could not go on any longer, and it should be settled in one way or the other. Since the Institution of Electrical Engineers' Model Conditions were published they were accepted by the B.E.A.M.A., and the I.M.E.A. was the only body that now held out against them, purely on account of the instruction

that the Council received two or three years ago from the members to which he had referred. Personally, he thought the time had now come to rescind that instruction, and he felt there was no objection at all in accepting provisionally the General Conditions. It was provided in these Conditions that individual buyers could vary them to suit their own requirements. They were model conditions only, and could be adapted to suit any special requirements, and in view of this he could not see any objection to the Association accepting them in that way and giving them a trial for a year or two.

Mr. H. Faraday Proctor (Hon. Sec.), who seconded, pointed out that at Bristol he had been working under the Conditions, as had many others, without any difficulty whatever. It saved a considerable amount of time and expense to have one stereotype form, not only to the manufacturers, but also to the Municipalities and those who were responsible for drawing up the contracts.

Mr. A. S. Blackman (Sunderland) regretted his inability to agree with the resolution. They would all remember a special meeting held two years ago, when the Council were instructed to take back the Conditions and refer them to the Association of Municipal Corporations, and they had now heard from Mr. Chattock that no definite answer had been received from that body, and it might be that this delay was due to the difficulty of satisfactorily amending the conditions that have been submitted to them. He would remind engineers that under the Model General Conditions a great deal was taken out of the hands of the purchaser. Contractors could deliver the machinery in pieces, and as it was delivered on site the buyer had to pay a very large proportion of the contract price. When purchasing material, as for instance, steel girders, the value of each consignment of which could be accurately ascertained, this would be fair, but in purchasing an article like a steam turbine, the whole value of which depended upon tests which could not be made until the plant was complete, this was not at all a reasonable state of affairs. It had been said that individual buyers could vary the Conditions to suit local requirements, but a good many of them had had experience of what that meant. Directly they approached the contractor to discuss the General Conditions, they would be met with the argument that they were most unreasonable people to deal with, and that the reasonableness of the Conditions was exemplified in the fact that their

own particular Association had adopted them. Thus the ground would be cut from under their feet if the members agreed to the general adoption of them, and he asked them to consider the matter very carefully. He saw no good reason in pushing them through that day, whilst, on the contrary, a great deal of harm might be done.

The President pointed out that it was not the fault of the I.M.E.A. that nothing had been done with the Association of Municipal Corporations. They had repeatedly asked the latter to deal with it, and had received no reply.

Mr. C. C. Atchison (Rochdale) said that the Association of Municipal Corporations represented very largely the legal opinion of Municipalities, and it had been mainly on his suggestion two years ago that the matter had been referred to that body. He understood now that the Association of Municipal Corporations had met representatives of the I.M.E.A., and had been through the General Conditions more than once. He further understood that the General Conditions had been knocked into shape, and that the Sub-Committee of the Law Committee of the Association of Municipal Corporations had at the present moment approved of the final draft. He could not understand, therefore, why the Council of the I.M.E.A., which he presumed was in close touch with the Sub-Committee mentioned above, could say that nothing had been done for two years, and he saw no reason why the ground should be cut from under their feet by passing Mr. Chattock's resolution. Meanwhile, he would suggest that instead of rescinding the instruction already given to the Council, members of the Association should be at liberty to take any action they might wish to with regard to their own conditions, and that any decision affecting the whole body of members should be left over until a proper report was brought up by the Council after the Conditions had been approved by the Sub-Committee of the Law Committee of the Association of Municipal Corporations.

Mr. F. W. Purse (Carlisle) associated himself most strongly with the previous speakers. As representing a small station he was surprised and astonished that this resolution should have been put forward.

Mr. Nichols Moore (Newport, Mon.) also expressed surprise that nobody outside the Council should have been aware that

the resolution was coming forward. He supported previous speakers mainly in the interests of the smaller undertakings but chiefly because now that the country had removed, and he hoped for all time, German and Austrian competition, it would be more than ever necessary that there should be General Conditions acceptable to all Undertakings, differing possibly from the Model General Conditions of the I.E.E. in so far as it is necessary to alter them to ensure that the smaller undertakings might hold their own with the British Manufacturers. The larger Undertakings could hold their own quite well for very obvious reasons and obtain almost any modification they required, but in practice it was not so with the smaller undertakings, and therefore it was these which would most often require protection. At least the matter should be deferred until the close of the war, when it should come forward again and be most thoroughly thrashed out.

Mr. T. Roles (Bradford), observing that a previous speaker had complained that the matter was sprung upon the Meeting, said that the question had been sprung upon the Council five minutes before they came to the Annual Meeting, and, as far as he was concerned, he did not agree with the resolution. The Bradford Corporation some years ago was engaged in a law case arising out of a contract, and had the Conditions of Contract been other than they were, it is very doubtful whether the decision would have gone in their favour as proved to be the case. The Bradford Town Clerk and other legal advisers did not approve of the Model General Conditions as they stood, and neither did he in view of the experience obtained by him in connection with the case above-mentioned. He agreed with a previous speaker that it was the small undertakings which would be likely to be the chief sufferers were these Model General Conditions adopted, as it was only a large Corporation which could afford to take the risk of fighting such a case as he had referred to in which the costs of the two parties totalled close upon £10,000. He had voted against the resolution in the Council, and wanted that vote put on record in order to justify himself before the Meeting and before his own Council at Bradford.

Councillor Jones (Kilmarnock) also expressed the opinion that these Conditions put the small undertaking at the mercy of the manufacturers, and it was just as well that the matter should be left over until it could be thrashed out. His Corporation has put through a number of contracts for machinery,

not on the terms of these Conditions, and if the Association recommended Municipalities all over the country to accept these Conditions, that would simply be playing into the hands of those from whom they had to buy the goods.

Mr. J. A. Robertson, (Salford) said he was very much surprised to find these Model Conditions of Contract now recommended for acceptance by the Council. The impression received by those who attended the special meeting two years ago was that the Council and the Association would take up a very strong attitude with regard to certain of the Conditions, and he was sure no one ever dreamt the Council would recommend their acceptance without amendment of any kind. They were living in abnormal times, and at present were compelled to accept any conditions imposed by the manufacturers. It would prejudice the position very seriously if these Conditions were accepted now. The Association of Municipal Corporations had placed the Council in a most humiliating position. He was prepared to move a resolution that the matter be deferred till after the war. The Council later on in the Report protested against the idea of Local Authorities being compelled to confine their purchase to goods manufactured within the Empire, but in any case there would be a strong public feeling after the war against Municipalities purchasing from abroad, and it was most essential therefore that the Model Conditions should be amended so as to make them absolutely fair to the purchaser as well as to the manufacturer.

Mr. Chattock said that as all the speakers seemed against the resolution, perhaps it would be better to withdraw it, and raise the matter again after the war. They might then have heard something from the Association of Municipal Corporations, and he was glad to hear that Mr. Atchison had apparently some internal knowledge of that Association which had not been communicated to the I.M.E.A. Perhaps he would let them know something about it.

Mr. H. Faraday Proctor, as seconder, said he was prepared to fall in with the proposal to withdraw the resolution. He wished to add, however, that the I.M.E.A. had not officially heard anything from the Association of Municipal Corporations on the matter ; although they had been in constant communication up to quite recently, they had always had the reply that nothing

had been done. If they had come to an agreement upon the matter, as was hinted by Mr. Atchison, without advising the Association, they had behaved to the I.M.E.A. in a manner which none of the members would approve. If they had done nothing, on the other hand, they ought to be ashamed.

Mr. Atchison said the position was that the Town Clerk of Rochdale was a member of the Sub-Committee of the Association of Municipal Corporations which was dealing with the General Conditions, and it was about two months ago that he was told the last revised proof had gone through.

The President pointed out that the Model General Conditions were issued by the Institution of Electrical Engineers, which was supposed to represent the whole body of the electrical industry; they were not issued on behalf of the B.E.A.M.A., although the speakers seemed to infer that this was the case. Another point about the matter was, that in days gone by, Municipal engineers had been able to have a contract in which they dictated the terms, *i.e.*, the engineer was to be the sole arbitrator of his own actions, and apparently some gentlemen still wished to continue in that position. It was necessary, however, to be fair and recognise that they could not have Conditions that were not equitable between the two parties. As the proposer and seconder had withdrawn their proposal, the matter would drop for the time being, and he hoped the Association of Municipal Corporations would hurry up and let the I.M.E.A. know something of what they were doing.

The resolution was then withdrawn.

The Eastbourne Accident and the Board of Trade.—**The President** said the Council had appointed a Committee which had been carefully going into the question of the recommendations issued by the Board of Trade in this matter, and he hoped before long they would be able to circulate the result of their deliberations. If any member would send further criticisms or remarks, the Council would be very pleased to have them.

Coal Supplies.—**Mr. R. A. Chattock** (Birmingham) said this paragraph of the Report made it clear what had been done up to recently. He understood that the steamer traffic was a good

deal easier now than it was a month or six weeks ago, and that the Government had done something in that direction. So far as the Local Committees and the difficulties of distribution however were concerned, there was still very great anxiety and difficulty experienced in entering into contracts, and ensuring a proper supply of coal for public utility undertakings. The I.M.E.A. Sub-Committee was still considering the matter, and was to approach the Government again to urge further steps being taken to ensure better supplies being given. There was a meeting about ten days ago on the subject, and a communication has already been sent in to the Government.

Councillor Sinclair (Swansea) said the Council's Report on this matter gave room for very great hopes for future results. It might be within the recollection of the Council that at the last meeting he mentioned the question of running contracts, and Bailie Smith had been kind enough to take it in hand, with the result that in the Limitation of Price Bill a clause was inserted safeguarding running contracts, which, in the case of Swansea alone, saved £1,000. For this reason he thought a hearty vote of thanks was due to the Council for the action they had taken in the matter, with special mention of Bailie Smith's name.

CONSTITUTION OF THE COUNCIL.—**Mr. F. W. Purse,** (Carlisle) said the Council had honoured him by referring to his name in the Report, and the President had referred to this matter in his address. He wished to put one or two facts before the meeting to justify in some way the position the small undertakings had endeavoured to take up. The Council stated that they were of the opinion that it would be unfortunate to draw any distinctions between members as representing the large or small undertakings or otherwise, and believed that satisfactory representation was gained under the existing Articles of Association. He was surprised that a responsible Council should put that forward as their one and only excuse. It seemed as if the smaller undertakings had to be shut out because the Council were afraid of hurting the tender feelings of some of them who did not like to be labelled a small station. Personally, he saw no reason to be ashamed of being in charge of a small station, because as long as he was producing good results what was the distinction to be drawn ? In 1914 the Council, reporting on the same matter, said that some alteration might be necessary in the matter of nominating new members of the Council, but if

they looked at the nomination papers this year they would see that of the nine members nominated by the Council, five had previously sat on the Council. It was, as had been remarked to him by another member, the same old gang re-electing one another. The majority of the Council in the past had been members of large stations, or men of long service on the Council. After quoting a number of sentences from a report of the Council on the matter, Mr. Purse said that if the opinions expressed therein were carried to their logical conclusion, it was not necessary to hold a business meeting at all, nor to re-elect the members of the Council, but to leave them as a standing body. In support of his point, however, that the smaller undertakings are not sufficiently represented on the Council, he stated that 238 members, representing towns with an output of less than five million units per annum, provided £250 out of £360 subscriptions to the Association, nearly 70 per cent., and yet this 70 per cent. of the members were only represented by 5 out of 24. In other words, 238 members had 5 representatives, and 104 all the rest. He would like to put another fact to the members of the Association. In the last printed list of the members there were 174 engineer members, out of which only 30 had been or were serving on the Council, and out of that 30, 17 were on the Council, yet in the nominations of the Council that day there were three previous members included. Although against none of them had he a word to say personally, yet the fact remained that these three had been selected, whereas there were 150 members who had never yet served on the Council. It was an extraordinary thing that during the last fifteen years existence of the Association, the membership of the Council had been confined to only thirty members of the Association. It had been suggested that a member was not elected because of the town he represented, but because of his ability. That he did not wish to dispute, but the men elected were known and seemed to be re-elected on account of their popularity. Nevertheless, it must be an honour to be on the Council, otherwise these gentlemen would not accept the position, and he felt that the honours ought to be distributed more widely. The Council of the Institution of Electrical Engineers was made up of representatives of members, associate members, and associates. The retort might be that there were only three associates on the I.E.E. Council, nevertheless there was the distinction, and in principle the same distinction had been recognised by the I.M.E.A., because the Articles of Association provided for men from non-County Boroughs being *nominated* for the Council

although it did not work out in practice that it ensured election. Why, however, should a man be excluded because he did not represent a city? In these views as to re-election of the Council, he was supported by the *Electrical Review* quite recently in regard to the Presidency of the I.E.E.

Finally on the question of the Postal Ballot, this was obviously the correct thing, because a man should not be disfranchised owing to his inability to attend the Annual Meeting.

Mr. Nichols Moore (Newport, Mon.) agreed with the views expressed by Mr. Purse. He could not but express his disappointment that after the manner in which the deputation, which he believed represented the concensus of opinion of the small undertakings, or, as he preferred to put it, the general body of members, had been received, and their views undoubtedly seriously discussed by the Council, that the only suggestion brought forward was that of a postal ballot. That in itself was very necessary, but as regards the better representation of small undertakings on the Council quite apart from the mere question of affording facilities to those members who could not attend the Council Meeting to exercise their right to vote, there was a good deal more that could be done in the direction of the views already expressed. During the Conference with the Council it was put forward by more than one member that the engineer to a large Undertaking was, *ipso facto*, a man of greater ability and experience and should therefore be on the Council. There was nothing particular to be said against this view, although he quite failed to see why all the experience and ability was necessarily by any means confined to the large Undertaking man. These men had of necessity worked up from small Undertakings. Further that the small Undertaking man was valued, was to be seen to-day from their representation on the Council of other institutions particularly the Association of Municipal Corporations. There the smaller towns had a representation of 74 per cent. as against 20 per cent. in the case of the I.M.E.A. A point to be remembered was that there are Local Authorities who are by no means satisfied with the value for money received as members of the I.M.E.A., and it would be a great pity if this view were to extend to other undertakings. It had also been put forward by the Honorary Secretary that further support was necessary if the Association was to fulfil its larger functions and that increased subscriptions would be needed for this purpose, and this fact should be remembered in connection

with the point raised. At the same time nobody was more alive to the fact than he that the large Undertaking men were essential to the proper progress of the Association, otherwise he suggested the Association would lose status. He contended strongly that there should be proper representation of the majority of the members, that is to say, the smaller Undertakings, and the representation from the larger Undertakings should form a powerful minority.

Mr. C. Turnbull (Tynemouth) whilst associating himself with the remarks of the previous speakers, said he would like to take away a certain bitterness in Mr. Purse's remarks, because during the fifteen years he had been a member of the Association, the Council had served the Association very well. He felt that to those who had constituted the Council in the past were due a very great debt of gratitude, notwithstanding that they had, for the most part, been representatives of large stations, because they had given the Association a status which it might not have otherwise obtained. Another aspect of the matter was that in the future he did not believe representatives of the larger stations would have the time to do the work required on the Council, and, perhaps, from this point of view the Council would do well if they followed the Institution of Electrical Engineers, and apportioned the seats on the Council to some extent amongst the stations according to size. However, he did not believe that any real discontent existed at the present time, but as a progressive body some such arrangement as he had suggested would help the general progressive tendency.

Mr. H. Faraday Proctor pointed out that the Council was entirely in the hands of the members in this matter. As the smaller stations were the predominating feature of the Association they would surely be in the position of voting anybody they pleased on the Council. They could go further, and by their vote alter the constitution of the Council in any form they liked. In his opinion the Council had by the nominations for next year's Council shown that they wished to have a fair representation of the small undertakings. On the ballot paper, taking small stations as 5,000 kw., there were 14 representatives of stations under that size and 14 of stations over that size, and this demonstrated that the Council held the view that the number of small stations represented should be increased. Taking a smaller basis, namely, 3,000 kw., there were 9 representatives of stations under that size and 19 over on the ballot sheet.

Mr. S. J. Watson (Bury) also expressed the hope that the members would approach this matter without any feeling of bitterness. He had very carefully considered this matter on more than one occasion, and could not help feeling that the smaller undertakings had some grievance, but on the other hand the serious grievance appealed to him in a different manner. He did not agree with the view that a small undertaking as such should necessarily be represented on the Council, because an undertaking which this year might be a small one might next year become quite moderate in size, and the changes in output from year to year made it extremely difficult to put into operation a scheme on such a basis. The manner in which it appealed to him was that as the membership was split up roughly into three or four categories, such as cities, county boroughs, boroughs and urban district councils, one member each year "should" be, and not "may" be, a representative of the Urban District Councils who, by reason of their numbers, were entitled to have a definite representation on the Council, irrespective of output or capacity, or anything of that kind.

The President said the position was that the Council had to put forward a certain number of names every year for consideration, in the form of a ballot sheet. The members were not obliged to elect these members, and they could add as many names as they pleased to the list, and vote for whom they liked. Therefore, the whole matter was entirely in the hands of the members, and there was no suggestion on the part of the Council that it should be otherwise. It was necessary to have on the Council a number of men of experience in Council work, but on the other hand it was necessary to have a steady flow of new blood. He had personally at many Conventions advocated that very course. The Council had recently carefully considered the matter from the point of view that Mr. Purse had put it, and could really see no advantage in changing the present policy.

Mr. C. C. Atchison agreed with the remarks of Mr. Watson, and moved: "That the Council be requested to reconsider the constitution of the Council, with a view to giving proportionate representation to Cities, County Boroughs, non-County Boroughs, Urban District Councils, and Rural District Councils."

The President said the Council had already very fully discussed the matter from that point of view, and there seemed to be grave objection to it.

The resolution was seconded.

Mr. H. Burnett (Barrow-in-Furness) whilst not agreeing that small stations had any particular grievance as to lack of representation on the Council, nevertheless believed there was a strong feeling amongst a considerable portion of the membership that there was not sufficient change in the constitution of the Council, and he moved an amendment that the Council consider the possibility in future in electing engineer members, of seeing that one-third were men who had not previously served on the Council, leaving two-thirds of the vacancies for engineers whose position or experience rendered it advisable to retain them.

The President said that all this could be settled on the ballot sheet by the members themselves without the Council taking any part in it.

Mr. C. C. Atchison said he did not mind what was done so long as the matter went back to the Council for consideration.

Mr. Burnett's amendment in the following terms :

> " That one-third of the ordinary engineering members of the Council elected annually shall be members who have not previously served on the Council."

was put to the meeting and declared lost.

Mr. E. E. Hoadley (Maidstone) moved another amendment. Whilst regretting the little tinge of bitterness which had been introduced into the discussion, he was certainly in favour of steps being taken to ensure adequate representation for the smaller undertakings. He recognised that there were difficulties in the way of classification, no matter what method was adopted, but he would like to move an amendment that the Council be requested to sympathetically consider the representation of the smaller undertakings, on the lines of giving a seat, or seats, on the Council to members representing undertakings in places having less than 50,000 inhabitants. There were objections to classifying on the basis of population, but he did not think there were so many objections as to the method proposed by Mr. Atchison, because, for instance, there were small cities and large cities, and the importance of the city varied considerably, and it was for this reason he suggested a population basis.

The President suggested that a way out might be that instead of the Council nominating one representative from a

non-County Borough, the resolution should read that one representative should be elected.

Mr. G. Wilkinson (Harrogate) proposed that the whole matter should be left in the hands of the Council to deal with.

Mr. H. S. Ellis (South Shields) seconded.

The President said the Council had appreciated the fact that the members only met once a year, and that this was the only opportunity they had of raising questions and criticising ; indeed, the Council expected it. At the same time, Mr. Purse must give the Council credit for having given the representatives of small stations a fair hearing. They occupied the time of the Council for nearly an hour, and there were a large number of other matters to deal with.

Mr. Atchison agreed to withdraw the resolution, and the matter was left to the Council to deal with.

Mr. Purse said he had no feeling on the matter beyond a desire to bring it forward.

Postal Ballot.—**The President** said the question now to be decided was whether the members desired a postal ballot, or whether they would prefer the present arrangement of electing by means of a ballot at the Annual Meeting. There were certain advantages of a postal ballot and certain disadvantages. It would mean that the ballot would have to be closed a fortnight before the Annual Meeting, and perhaps some members would not like that at all.

Councillor Barge (Poplar) said that he regarded this as part of the previous proposal to leave the matter in the hands of the Council.

The President said he would prefer an expression of opinion from the meeting.

Mr. F. W. Purse proposed that the Council be instructed to make the necessary alteration in the Articles of Association, providing for a ballot being taken on the same lines as that of

the Institution of Electrical Engineers. He did not see that there was any difficulty as regards closing the ballot, because it would not be necessary to do so until the morning of the first day of the Annual Meeting, so that those attending the meeting could bring their ballot papers with them, and those who were unable to attend could post their ballot papers. Last year, for instance, he was unable to get away to the meeting, and was deprived of his vote in consequence.

The proposal was seconded, and on being put to the meeting was declared to be carried.

British Trade after the War.—**Alderman Walker** (Manchester) said he had been requested to move the following resolution :

> "Resolved that this Convention of the Incorporated Municipal Electrical Association urges the Government to take adequate steps to deal with the Industrial Situation which will arise immediately peace is declared.
>
> "This Association represents practically every Municipality in the Kingdom operating Electricity Departments. Over £36,000,000 (Thirty-six million pounds) is invested in these undertakings, and the property of the Departments is dependent on the Manufacturing and Commercial sections of the community."

Continuing, Alderman Walker said none of them had any desire to drift into peace as the country had drifted into war, but it was obvious that unless steps were taken to deal with the situation which would arise immediately peace was declared, the chaos in the industrial community would be equal to the chaos which existed with regard to munition supplies at the beginning of the war. He believed the resolution would meet with general support, and he was glad to say that at a very early date an opportunity would be given to the engineering departments of the Corporations and Municipalities of the country to take part in the general engineering reorganisation of the Empire ; for the first time there would be for the public departments an opportunity of combining with the manufacturers and the consultants, and taking part in the political—in its non-offensive sense—side of the industry. He therefore asked the Association to lend its weight and its opinion to get the Government to take the necessary means to deal with the situation which would arise.

Alderman Smith (Liverpool) said he did not know why they always wanted the Government to do something. Why did not they do something themselves? The Association represented all municipalities with an enormous weight of public opinion behind it. The previous speaker had said we must not drift into peace as we drifted into war. We did not drift into war: we were shoved into war, and the country would be shoved into peace, and a most unsatisfactory one, if everybody left it to somebody else to do something. He did not believe in resting upon anybody else. If he wanted a job done he set about doing it himself, and if there were people in the way he would try to stamp them flat if they would not get out of the way. Therefore, he urged the Association and its members to do everything they could to help bring about the position which they desired, and one way to do this was to educate and instruct the manufacturers of the country to do what was required, and to take German and Austrian appliances for no purpose whatever.

Mr. H. Dickinson (Liverpool), who seconded the resolution, did not think Alderman Smith had gone far enough. The Association could do, and ought to do, its utmost to encourage trade after the war. What was necessary was to educate the Government, and change its attitude absolutely in the future with regard to trade questions. In his opinion, the policy had been in the past to neglect trade, but that would not do for the future. The power of a Government is such that it is difficult to put a limit to its scope. It should use that enormous power to develop and encourage the trade of the country. If this were done, such an advancement in the trade would be witnessed that it would be worth everything. Hitherto manufacturers in the country had been under a pall which had of necessity created an over-cautiousness. This had been going on for years and years, until the over-cautiousness had become almost a habit. The manufacturers were up against all sorts of troubles, dumping, and one thing and another, and there had been no assistance by the Government to encourage them. A radical change of opinion on the side of the Government towards the industry was essential, and if this could be brought about, there would after the war be a boom of trade in this country which would have an enormous effect all round.

Bailie Jones (Kilmarnock) said the point to be remembered was that we were pushed into this war as an unorganised

nation, and it had been necessary to spend almost two years in putting our house in order, and getting ourselves ready to face the hostile forces that had been organising for over thirty years. In his opinion, the country had been duped for many years past, and had been assisting in organising Germany in her preparations for this war by the trade we had been doing with her. It was no good Chambers of Commerce and other organisations saying what they would do after the war, if the Government did nothing, as it had done in the past. It was the business of the Association to support the Government and get them to take action. The Government had organised the army without asking leave of the nation, and the nation had bowed to their decision. They had organised munitions, and now it was time, in view of peace coming, as he believed, at an early date, to get ready for it, and the only way to be thoroughly ready was to ask the Government to make arrangements, so that there would be no chance of any one man or body taking advantage of another. There should be no difficulty whatever in preventing any goods from Germany, Austria, or Turkey coming into this country, and we had plenty of friends in our colonies and allies which should make us independent of anything that hitherto came from enemy countries. For this reason he strongly supported the resolution of Alderman Walker.

The proposal was put to the meeting, and carried unanimously.

Mr. G. Wilkinson (Harrogate) asked to whom the resolution was to be addressed.

Alderman Walker said it would be better to send it direct to the Board of Trade, because he had been giving evidence on two occasions lately before Sub-Committees of the Board of Trade which were preparing reports on the matter.

Alderman Smith (Liverpool) suggested that the resolution should also be sent to the Prime Minister.

Financial Organisation.—**Mr. W. Wyld** (Hampstead) said that this was a matter of great importance which had been under consideration by the Council in conjunction with some of the other Municipal Associations, and he wished to move a resolution to assist the members who were suffering in different parts of the country from the insidious attempts which were being made to interfere with the financial control and accountancy of Electric Supply Departments.

The resolution was as follows:

> "That this Association views with concern the repeated attempts made by the Finance Departments of various Municipalities to encroach upon the work of the Trading Departments, and is of opinion that it is necessary the books and accounts should be kept by the departments concerned if the work is to be efficiently and economically carried out and that any proposed legislation in a contrary direction should be strenuously opposed"

As Honorary Secretary of this Sub-Committee, a number of communications had been received, and he felt it would support those members who were affected if some such resolution as this was passed.

The resolution having been seconded, was put to the meeting and carried unanimously.

There being no further points raised on the Report or questions on the Balance Sheet, the Report of the Council and of the Auditors was put to the Meeting and declared to be carried unanimously.

PLACE OF MEETING NEXT YEAR.—It was decided to leave in the hands of the Council the fixing of the place of meeting next year.

ELECTION OF AUDITORS.—The Auditors, Messrs. Bolton, Pitt and Breden, were re-elected.

ELECTION OF OFFICERS AND COUNCIL.—The Scrutineers' report was received shewing the result of the ballot for Officers and Members of Council for the year 1916–17 to be as follows:—

President.
F. M. Long, Norwich.

Vice-Presidents.
S. J. Watson, Bury.
F. Ayton, Ipswich.

Past Presidents.
R. A. Chattock, Birmingham.
H. Richardson, Dundee.
A. C. Cramb, Croydon.

Members of Council.
J. W. Beauchamp, West Ham.
A. S. Blackman, Sunderland
S. E. Britton, Chester.
W. W. Lackie, Glasgow.
S. L. Pearce, Manchester.
W. A. Vignoles, Grimsby.
S. T. Allen, Wolverhampton.
J. Christie, Brighton.
J. H. Bowden, Poplar.
Councillor H. R. Barge, Poplar.
Alderman Sir J. Beecham, St. Helen's.
Councillor Sinclair, Swansea.
Alderman Walker, Manchester.
Bailie W. B. Smith, Glasgow.
Councillor T. G. Evans, Sheffield.

Hon. Secretary.
H. Faraday Proctor.

Hon. Solicitor.
Alderman G. Pearson, Bristol.

Hon. Treasurer.
J. E. Edgcome, Kingston-upon-Thames.

PREFERENTIAL CHARGING.—**Mr. H. Faraday Proctor** (Hon. Secretary) said the Borough of Hackney had been in correspondence with the Association with reference to a case of alleged preferential charging which was threatened against them by a gas company in their district. This case was the exact converse of the Long Eaton case, and the Council, having gone into it and taken counsel's opinion on it, had come to the conclusion that the case for Hackney was entirely good. What was alleged against Hackney was that they were showing preference by their published rates of charging, whereby they allowed lighting consumers a lower charge when they took a power supply also. That was the direct converse of Long Eaton, which was a case in which the charge for power was reduced when lighting was also taken exclusively or throughout. In the Long Eaton case Mr. Justice Sargent, in his summing-up, said any circumstances which render it less costly, or otherwise more profitable to supply "A" than "B," constitute a legitimate reason for making a lower charge to "A" for the same supply, and if the Court once came to the conclusion that such circumstances existed, then proof would not be required that the diminution in the charge was precisely equivalent to the diminution in the cost of the supply. In the Hackney case it would be obvious that the cost for a joint supply of electricity for lighting plus power would be less than that for lighting alone, and that there was justification for a reduction in the charge.

At the present time it was not known whether the gas company would go on with the case. It seemed extremely probable that having had a better opportunity of looking at the matter they would climb down, and that nothing more would be heard of it, but the Council had passed a resolution, and thought it very desirable that the members of the Association in general meeting should confirm it, promising to give Hackney its moral support, and at the same time the Council recommended the members to give, if need be, financial support. They were firmly convinced that the gas company was on very unsound ground in this matter, and that the Local Authority was quite safe. It would be ridiculous to suggest that lighting could not be charged for in the case of a power consumer at a lower rate than that of a consumer who took electricity for lighting only. This had been authorised for years. By every Power Company's Act, namely, that where a supply for power was given, then a supply for lighting could be given at the same rate up to a certain percentage of the total supply, 10 or 20 per cent., he

believed. He therefore wished to move a resolution to the effect that they should give Hackney support in the matter, and if necessary give financial support, and also evidence in the event of there being a fight.

Mr. J. E. Edgcome (Kingston-upon-Thames) seconded, and the resolution was carried unanimously without discussion.

HONORARY MEMBER.—**The President** announced that the Council had elected Mr. A. B. Mountain, of Huddersfield, an honorary member, on his giving up municipal work.

LOAN PERIODS.—**Mr. C. C. Turnbull** (Tynemouth) moved the following resolution :

> " That the Council make representations to the proper authority that, on account of conditions arising out of the War, it is desirable that the loan period for electricity works be extended."

Continuing, Mr. Turnbull said that members would probably have seen in the papers recently that Edinburgh, having a loss of about £17,000, were able to meet it by extending their loan period from twenty-five to thirty years. He explained that the 30 year period had been voluntarily reduced some years ago to twenty-five years. In the present time of stress, however, they had reverted to thirty years. In his opinion, there was no difference from the engineering point of view between England and Scotland. Plant lasted just as long in one country as in the other. Many towns in England were suffering losses owing to war conditions, and unless something was done the ratepayers would be badly hit. This might lead to temptation in many cases to sell Municipal Undertakings to companies, but if periods of loan could be extended by five years, it would tide over the period of difficulty. It might be asked if it was sound financially to do this, but in this connection he would draw attention to two stations, namely, those at Hove and Winchester. They were both stations over ten years old with very large capital expenditures, and both had been purchased from companies by corporations. In both cases, he believed he was right in saying, they had been allowed a thirty years' loan period in which to pay off the original debt. This practically gave the plant a life of forty years, and on this basis he did not see why in war time other stations could not be allowed up to thirty years.

Mr. W. C. P. Tapper (Stepney) seconded.

Mr. F. A. Newington (Edinburgh) stated that although there had been a loss for the present year at Edinburgh he did not agree with Mr. Turnbull that this amounted to £17,000 due to the large reduction in lighting; the actual loss being about £8,000. The Corporation had decided that they would go back to the thirty years loan period for this year only, instead of the twenty-five years, which they had voluntarily adopted previously. In doing this, however, they knew they were in a perfectly sound financial position, as their reserve fund was quite full, but he did not believe the Corporation would have asked for powers to extend the period if they had not already got them.

On a show of hands the resolution was declared lost.

Votes of Thanks.—On the motion of Alderman Walker (Manchester), seconded by Alderman Leese (Stoke-on-Trent), a vote of thanks was accorded to the President for his services as President and also Acting-President during the past two years.

A vote of thanks was also passed to the Institution of Electrical Engineers for allowing the Association the use of its rooms for their meetings.

The proceedings then terminated.

LIST OF MEMBERS AND DELEGATES ATTENDING THE I.M.E.A. MEETINGS IN LONDON, JUNE 22ND AND 23RD, 1916.

LOCAL AUTHORITIES REPRESENTED.

Aylesbury
Ashton-under-Lyne
Barking
Barnes
Barrow-in-Furness
Batley
Beckenham
Bedford
Belfast
Birmingham
Blackburn
Bolton
Bradford
Brighton
Bristol
Burton-upon-Trent
Bury
Canterbury
Cardiff
Carlisle
Cheltenham
Chester
Chesterfield
Coventry
Croydon
Darlington
Dartford
Darwen
Derby
Dewsbury
Dover
Ealing
Eastbourne
Eccles
Edinburgh
Erith
Exeter
Fleetwood
Glasgow
Gravesend
Great Grimsby
Greenock
Halifax
Hampstead
Harrogate
Hastings
Hereford
Heston & Isleworth
Hornsey
Hove
Ilford
Ipswich
Keighley
Kilmarnock
Kingston-upon-[Thames
Leek
Leicester
Leyton
Lincoln
Liverpool
Londonderry
Luton
Maidenhead
Maidstone
Manchester
Middlesbrough
Morecambe [Lyne
Newcastle-under-
Newport (Mon.)
Norwich
Nottingham
Nuneaton
Pembroke (Dublin)
Poplar
Portsmouth
Reading
Radcliffe
Rochdale
Salford
Sheffield
Shipley
Southampton
South Shields
St. Annes-on-Sea
St. Helen's
Stockton-on-Tees
Stoke-on-Trent
Stepney
Stretford
Sunderland
Swansea
Todmorden
Tunbridge Wells
Tynemouth
Wakefield
Walsall
Warrington
Watford
West Bromwich
West Ham
Willesden
Wimbledon
Winchester
Wolverhampton
Woolwich
Worcester
Worthing
York

ENGINEER MEMBERS, HON. MEMBERS AND ASSOCIATES.

Engineer Members.—R. L. Acland, Chesterfield ; C. C. Atchison, Rochdale ; Sidney Allen, Wolverhampton ; H. W. Angus, Eccles ; A. W. Annetts, Morecambe ; F. Ayton, Ipswich ; R. Ayton, Winchester ; W. J. Bache, Cheltenham ; A. W. Barham, Watford ; J. W. Beauchamp, West Ham ; J. Bemrose, Leek ; W. C. Bexon, Kilmarnock ; A. S. Blackman, Sunderland ; A. W. Blake, Willesden ; C. A. Blascheck, Canterbury ; T. W. Bloxam, Belfast ; J. H. Bowden, Poplar, E. ; S. E. Britton, Chester ; J. K. Brydges, Eastbourne ; H. R. Burnett, Barrow-in-Furness ; W. A. Burr, Swansea ; R. H. Campion, Dewsbury ; R. A. Chattock, Birmingham ; J. Christie, Brighton ; Stanley Clegg, Lincoln ; J. H. Clothier, St. Annes-on-Sea ; W. H. Cooke, Luton ; A. C. Cramb (*Pres.*), Croydon ; G. F. Craven, Reading ; C. S. Davidson, Mortlake, S.W. ; A. J. C. De Renzi, Newcastle-under-Lyne ; H. Dickinson, Liverpool ; J. E. Edgcome (*Hon. Treas.*), Kingston-upon-Thames ; H. S. Ellis, South Shields ; S. E. Fedden, Sheffield ; R. F. Ferguson, Hastings ; W. S. Foale, Portsmouth ; T. Hall, Burton-upon-Trent ; J. W. Hame, York ; E. E. Hoadley, Maidstone ; E. M. Hollingsworth, St. Helen's ; H. A. Howie, Walsall ; W. A. Jackson, West Bromwich ; W. T. Kerr, Hereford ; J. D. Knight, Ealing, W. ; W. W. Lackie, Glasgow ; H. Tomlinson Lee, Wimbledon ; F. M. Long, Norwich ; J. R. P. Lunn, Darlington ; R. V. Macrory, Londonderry ; F. V. L. Mathias, Warrington ; C. F. McInnes, Gravesend ; H. W. Miller, Fleetwood ; A. Nichols Moore, Newport, Mon. ; H. D. Munro, Exeter ; H. A. Nevill, Wakefield ; F. A. Newington, Edinburgh ; S. L. Pearce, Manchester ; J. D. Pember, Dartford ; R. W. L. Phillips, Bedford ; G. Porter, Worthing ; S. L. R. Price, Pembroke (Dublin) ; H. Faraday Proctor (*Hon. Sec.*), Bristol ; F. W. Purse, Carlisle ; W. Redman, Shipley ; J. A. Robertson, Salford ; W. M. Rogerson, Halifax ; T. Roles, Bradford ; P. E. Rycroft, Hounslow ; R. H. Scotson, Middlesbrough ; A. H. Shaw, Ilford ; C. M. Shaw, Worcester ; C. B. Smith, Hove ; J. J. Smith, Stockton-on-Tees ; T. R. Smith, Leicester ; N. Staniland, Hornsey ; H. F. Street, Southampton ; Herbert Talbot, Nottingham ; J. E. Tapper, Beckenham; W. C. P. Tapper, Stepney ; R. N. Torpy, Tunbridge Wells ; G. Tough, Coventry ; C. Turnbull, Tynemouth ; W. A. Turnbull, Aylesbury ; S. J. Watson, Bury ; H. Webber, Keighley ; P. P. Wheelwright, Blackburn ; F. H. Whysall, Greenock ;

G. Wilkinson, Harrogate ; H. Wilkinson, Radcliffe ; T. P. Wilmshurst, Derby ; W. J. H. Wood, Bolton ; L. W. Woodman, Dover ; W. Wyld, Hampstead ; C. H. Yeaman, Stoke-on-Trent.

Hon. Members.—J. H. Rider, London ; Sir J. F. C. Snell, London ; C. H. Wordingham, London.

Associates.—J. Boyce, Todmorden ; A. S. Channon, Grimsby ; S. Derwen Jones, Batley.

COMMITTEE MEMBERS AND DELEGATES.

Ashton-under-Lyne, Alderman Coop ; Barking, W. E. Kidner ; Barrow-in-Furness, Alderman J. P. Smith ; Bedford, Alderman S. L. Kilpin ; Belfast, Councillor J. McCaughey, Councillor W. McEley, Councillor John Hanna ; Birmingham, Alderman Ellaway, Alderman Jephcott, Councillor Burman, H. Foulds ; Blackburn, Councillor Higham ; Bradford, Alderman George Henry Robinson, J.P., Councillor Joseph Haley ; Brighton, Councillor Lintott ; Bristol, Alderman G. Pearson, Alderman Lloyd, Councillor J. Littleton, Councillor J. Milton ; Bury, Councillor Jamieson ; Burton-upon-Trent, Councillor J. H. King ; Chesterfield, Councillor J. E. Clayton ; Coventry, Councillor Lee, Councillor Orton, Alderman West ; Croydon, Councillor H. W. Umney, Councillor W. Peet, Alderman D. B. Miller, J.P., Councillor T. Betteridge ; Dewsbury, Councillor J. E. Kilburn ; Eccles, Alderman William Pearson ; Edinburgh, Councillor Bruce Lindsay ; Erith, Councillor J. W. Williams ; Glasgow, Bailie W. B. Smith, Bailie W. H. Hannay, Bailie P. G. Stewart, D. Stenhouse ; Gravesend, Alderman Frank Goldsmith, J.P. ; Greenock, Councillor McCallum, Councillor Connal ; Grimsby, Councillor F. Moss ; Halifax, Alderman C. F. Spencer, Alderman A. Fawcett ; Hereford, Councillor Ernest Wilfred Langford, Councillor Edmund Robert Dymond ; Hornsey, Councillor R. Moritz, Alderman Wilson ; Harrogate, Councillor Lofthouse ; Hove, Councillor J. J. Clack ; Ilford, Councillor G. W. Davis, J.P. ; Kingston-upon-Thames, Councillor G. A. Kerrison, Councillor Cheyney ; Keighley, Councillor H. Whitehead ; Kilmarnock, Bailie Jones ; Leyton, Councillor A. W. Golightly ; Liverpool, Councillor Edward Russell-Taylor ; Alderman Frederick Smith ; Luton, Alderman Wilkinson ; Maidstone, Councillor E. Vaughan ; Manchester, Alderman

Walker ; Nuneaton, H. Hodges ; Poplar, Councillor H. R. Barge ; Salford, Councillor G. Billington ; St. Annes-on-Sea, Councillor R. Leigh, J.P. ; St. Helens, Alderman Sir Joseph Beecham ; Sheffield, Councillor T. G. Evans ; Southampton, Alderman Kimber ; South Shields, Alderman Rennoldson ; Stockton-on-Tees, Councillor Bertrand Watson ; Stoke-on-Trent, Alderman Leese ; Stretford, R. Rowland ; Sunderland, Councillor W. Yorke ; Swansea, Councillor A. Sinclair, Alderman C. H. Colwill ; Todmorden, Alderman W. Wadsworth, Councillor A. Brookes ; Tynemouth, Councillor R. Irwin ; Wakefield, Councillor H. Womersley ; Warrington, Councillor Dr. Joseph, Councillor Wilkinson ; West Ham, Councillor G. H. Fennell, J.P., Councillor G. Kensett ; Wimbledon, Alderman Stuart ; Winchester, Councillor A. Edmeades ; Wolverhampton, Councillor R. Gibson ; Woolwich, Councillor H. H. Dawson ; Worcester, Councillor W. J. Hill.

Several of the co-opted members of the Electric Vehicle and Development Committees of the I.M.E.A., and other gentlemen specially interested in the subjects under consideration, were present by invitation of the Council.

Incorporated Municipal Electrical Association.

FOUNDED 1895. INCORPORATED 1901.

LIST OF MEMBERS, 1916.

(Those Municipalities in large type are represented on this Council.)

COMMITTEES.

Date of Election.		Date of Election.	
1905	Aberdeen	1896	BRISTOL
1902	Accrington	1896	Burnley
1901	Ashton-under-Lyne	1906	
1916	Aylesbury	1904	Burton-upon-Trent
1897	Ayr	1899	BURY
1906	Barking	1910	Cambuslang
1900	Barnsley	1907	Canterbury
1898	Barrow-in-Furness	1897	Cardiff
1897	Bath	1900	Carlisle
1906	Beckenham	1896	Cheltenham
1896	Bedford	1898	CHESTER
1902	Birkenhead	1901	Chesterfield
1904	BIRMINGHAM	1912	Clacton-on-Sea
1908	Blackburn	1900	Colchester
1897	Blackpool	1900	Colne
1896	Bolton	1912	Colwyn Bay
1903	Bolton Tramways	1896	Coventry
1902	Bootle	1909	Crewe
1903	Bournemouth Tramways	1896	CROYDON
1896	Bradford	1900	Darlington
1909	Bridlington	1914	Dartford
1896	BRIGHTON	1898	Darwen

Date of Election.	
1898	Derby
1896	Dewsbury
1901	Doncaster
1906	Dover
1903	Dublin
1901	DUNDEE
1899	Ealing
1900	Eastbourne
1904	Eccles
1901	Edinburgh
1908	Epsom
1903	Erith
1897	Exeter
1905	Falkirk
1904	Fulham
1908	Gillingham
1896	GLASGOW
1903	Gloucester
1904	Gravesend
1899	GREAT GRIMSBY
1908	Greenock
1896	Halifax
1897	Hammersmith
1912	Hampstead
1897	Harrogate
1899	Hastings
1902	Heckmondwike
1912	Hereford
1914	Heston & Isleworth
1902	Heywood
1908	Hornsey
1908	Horsham
1915	Hove
1901	Hoylake
1896	Huddersfield
1897	Hull
1902	Hull Tramways
1902	Ilford
1903	Ilkeston
1916	Ilkley
1906	Keighley
1907	Kilmarnock
1906	King's Lynn
1896	KINGSTON-UPON-THAMES
1902	Lancaster
1901	Leeds
1905	Leek
1911	Leicester
1901	Leigh
1908	Leith
1901	Leyton
1897	Lincoln
1896	Liverpool
1903	Londonderry
1906	Loughborough
1899	Lowestoft
1896	Luton
1897	Maidenhead
1902	Maidstone
1896	MANCHESTER
1904	Mansfield
1913	Melbourne, Australia
1902	Middlesbrough
1902	Middleton
1898	Morley
1901	Motherwell
1902	Nelson

Date of Election.	
1897	Newport (Mon.)
1907	Northampton
1909	NORWICH
1903	Nottingham
1902	Nuneaton
1903	Oldham
1909	Pembroke (Dublin)
1896	Plymouth
1908	Pontypridd
1912	POPLAR
1904	Portsmouth
1901	Reading Tramways
1908	Radcliffe
1910	Rawtenstall
1896	Rochdale
1897	Rotherham
1897	Salford
1904	SHEFFIELD
1901	Shipley
1897	Southampton
1896	Southend-on-Sea
1897	Southport
1902	South Shields
1903	St. Annes-on-Sea
1898	ST. HELENS
1899	St. Pancras
1903	Stockton
1903	Stoke-on-Trent
1898	Stockport
1896	SUNDERLAND
1913	Sutton Coldfield
1902	SWANSEA
1902	Swindon
1896	Taunton
1909	Todmorden
1897	Torquay
1896	Tunbridge Wells
1903	Tynemouth
1901	Wakefield
1896	Wallasey
1896	Walsall
1908	Warrington
1897	Watford
1913	West Bromwich
1897	WEST HAM
1906	Weymouth
1912	Whitehaven
1901	Wigan
1900	Willesden
1908	Wimbledon
1912	Winchester
1906	Wishaw
1898	WOLVERHAMPTON
1906	Woolwich
1896	Worcester
1913	Worksop
1903	Wrexham
1901	York

ELECTRICAL ENGINEERS (MEMBERS).

Names of Members of Council are in larger type.

Date of Election.		
1901	Acland, R. L.	Chesterfield
1900	Atchison, C. C.	Rochdale
A 1902 M 1908	ALLEN, SIDNEY ..	Wolverhampton
1909	Allen, W. H.	Loughborough
1902	Angus, H. W.	Eccles
1914	Annetts, A. W.	Morecambe
1906	AYTON, F. (*Junior Vice-President* 1916)	Ipswich
1912	Ayton, R.	Winchester
1903	Bache, W. J.	Cheltenham
1913	Barham, A. W.	Watford
1903	Barker, E. A.	Barnsley
1910	BEAUCHAMP, J. W ..	West Ham
1913	Beckett, A. J.	Bridlington
1903	Bell, H.	Hull
A 1896 M 1899	Bell, J. A.	Aberdeen
1913	Bellamy, L. C. F. ..	Ilkeston
1914	Bemrose, J.	Leek
1912	Bexon, W. C.	Kilmarnock
1916	Bill, S. H.	Ilkley
1908	Black, A. S.	Southport
1896	BLACKMAN, A. S. ..	Sunderland
1912	Blake, A. W.	Willesden
1907	Blascheck, C. A... ..	Canterbury
1908	Bloxam, T. W.	Belfast
1908	Bolam, J. H.	Weymouth
1906	BOWDEN, J. H. ..	Poplar, E.
1901	BRITTON, S. E. ..	Chester
1916	Brown, R. A.	Falkirk
1898	Brydges, J. K. (*Past Member of Council* 1908)	Eastbourne

Date of Election.		
1905	Bulfin, I.	Bournemouth
A 1896 M 1898	Burnett, H. R.	Barrow-in-Furness
1915	Burr, J. W.	Swansea
1901	Calvert, E.	Finchley, N.
1902	Campion, R. H. ..	Dewsbury
1907 1913	Chalmers, A. D... ..	Gillingham
1900	CHATTOCK, R. A. (*Past President* 1913–14)	Birmingham
M 1895 A 1898 M 1900	CHRISTIE, J. .. .. (*Past President* 1911.)	Brighton
A 1896 M 1898	Clegg, Stanley	Lincoln
1902	Clothier, J. H.	St. Annes-on-Sea
A 1898 M 1902	Clothier, T. D.	Bootle
1902	Cooke, W. H.	Luton
A 1895 M 1900	Cooper, A. G.	Colne
1914	Corson, F. H.	Gloucester.
A 1900 M 1904	CRAMB, A. C. .. .. (*Past President* 1915–16)	Croydon
1913	Craven, G. F.	Reading
1909	Cross, E.	Rotherham
1900	Crowther, J. A... ..	Wallasey
1901	Crowther, J. P.	Worksop
1902	Davidson, C. S... ..	Barnes.
1913	De Renzi, A. J. C. ..	Newcastle-under-Lyne
1896	Dickinson, H. (*Past Vice-President* 1901)	Liverpool
1908	Dimmack, A.	Swindon
1895	EDGCOME, J. E. (*Hon. Treas.* (*Past Hon. Secretary* 1904, *Past Pres.* 1906)	Kingston-upon-Thames

Date of Election.		
1895	Ellis, A. (*Past Member of Council* 1902)	Cardiff
1912	Ellis, H. S.	South Shields
1909	Everitt, H. W.	Clacton-on-Sea
A 1896 M 1899	Fedden, S. E. .. (*Past President* 1907)	Sheffield
1903	Ferguson, R. F. ..	Hastings
1903	Foale, W. S.	Portsmouth
1909	Francis, O. F.	Kirkcaldy
1899	Furness, C. (*Past Member of Council* 1914)	Blackpool
1905	Garside, F.	Aldershot
1912	Gibson, S. Cameron ..	Nuneaton
1903 1913	Gilling, A. C.	Epsom
1906	Goslin, E. T.	Glasgow Trams
1901	Grey, H.	Accrington
1911	Hall, T.	Burton-upon-Trent
A 1906 M 1908	Hame, J. W.	York
1906	Hatton, E.	Newcastle-upon-Tyne
1904	Hewlett, E. H.	Mansfield
A 1898 M 1900	Hoadley, E. E. (*Past Member of Council* 1907)	Maidstone
1910	Hogarth, L. B.	Whitehaven
A 1899 M 1903	Hollingsworth, E. M. ..	St. Helen's
1914	Holmes, W.	Barking
1914	Howie, H. A.	Walsall
1907	Jackson, W. A	West Bromwich
1913	Kay, Barnes	Haslingden
1914	Keats, G. W.	Woolwich
1909	Kerr, W. T.	Hereford
1903	Kinghorn, D. M. ..	Southwark, S.E.
1900	Knight, J. D.	Ealing, W.

Date of Election.		
A 1896 AM 1898 M 1905	LACKIE, W. W. .. (*Past President* 1910)	Glasgow
1906 1913	Leach, R. B.	Heywood
1913	Lee, H. Tomlinson ..	Wimbledon
1898	Lewis, F. H.	Leytonstone, E.
1909	Lomax, R.	Stockport
1908	Long, E. D.	Grays Thurrock
1903	LONG, F. M. (*President* 1916-17)	Norwich
A 1896 M 1901	Lunn, J. R. P.	Darlington
1901	Macrory, R. V.	Londonderry
1903	Marshall, R.	Ayr
1908	Mathias, F. V. L. ..	Warrington
1914	May, W. R.	Lowestoft
1903	McInnes, C. F.	Gravesend
1913	Miller, W. H.	Fleetwood
1911	Milnes, G. C.	Lancaster
1912	Moore, A. Nichols ..	Newport, Mon.
1896	Munro, H. D.	Exeter
1913	Nayler, G. F.	Nelson
1909	Nevill, H. A.	Wakefield
1896	Newington, F. A. (*Past President* 1905)	Edinburgh
A 1897 M 1901	Okell, E. G.	Plymouth
1905	Page, A.	Glasgow
1910	Papworth, J. W. ..	Stirling
1898	Parkinson C. F. ..	Paisley
1904	Pauls, S.	Middleton
AM 1903 M 1904	PEARCE, S. L. .. (*Past-President* 1909)	Manchester

Date of Election		
1901	Pember, J. D.	Dartford
A 1896 M 1902	Phillips, R. W. L. ..	Bedford
1909	Pickersgill, A.	Cleckheaton
1909	Pickvance, G.	Wrexham
1906	Plunkett, M. P.	Tonbridge
1914	Porter, G.	Worthing
1912	Price, S. L. R.	Pembroke (Dublin)
1895	PROCTOR, H. FARADAY (*Hon. Secretary, Past Pres.* 1899)	Bristol
1909	Purse, F. W.	Carlisle
1904	Rayner, E. S.	Doncaster
1913	Redman, W.	Shipley
1904	RICHARDSON, H. .. (*Past President* 1915)	Dundee
1904	Robertson, J. A. ..	Salford
1902	Robinson, L. L.	Hackney, N.E.
1902	Rogerson, W. M. ..	Halifax
1908	Roles, T. (*Past Member of Council* 1916)	Bradford
1902	Ruddle, M.	Dublin
1904	Rutherford, A. P. ..	Leith
1911	Rycroft, P. E.	Heston and Isleworth
1911	Salt, C. W.	Torquay
1908	Sankey, B.	Port Elizabeth
1916	Scotson, R. H.	Middlesbrough
1902	Seabrook, A. H. .. (*Past Vice-Pres.* 1916)	St. Marylebone
M 1897 A 1898 M 1915	Shallcross, G. P.	Birkenhead
1901	Shaw, A. H.	Ilford, E.
1903	Shaw, C. M.	Worcester
1906	Slevin, J.	Wigan

Date of Election.		
1914	Smith, C. B.	Hove
1903	Smith, J. J.	Stockton-on-Tees
1912	Smith, T. R.	Leicester
1903	Spark, J. W.	West Hartlepool
1904	Staniland, N.	Hornsey, N.
1906	Starkie, J. E.	Burnley
1910	Stewart, C. L. E., ..	Rawtenstall
1910	Stokes, H. P.	Bexley Heath
1901	Street, H. F.	Southampton
1895	Talbot, Herbert.. .. (*Past President* 1908)	Nottingham
1909	Tapper, J. E.	Beckenham
A 1896 M 1900	Tapper, W. C. P. ..	Stepney, E.
1898	Teague, F.	Bath
A 1896 M 1906	Teasdel, J. E.	Pontypridd
1913	Torpy, R.N.	Tunbridge Wells
1910	Tough, G.	Coventry
1909	Tudman, A. R. ..	Colwyn Bay
1900	Turnbull, C.	Tynemouth
1916	Turnbull, W. A.	Aylesbury
1907	Turner, C.	Hoylake
1901	VIGNOLES, W. A. ..	Grimsby
1911	Walker, W. A.	Kettering
1898	WATSON, S. J. .. (*Senior Vice-President* 1916)	Bury
1910	Webber, H.	Keighley
AM 1904 M 1905	Wheelwright, P. P. ..	Blackburn
1909	Whysall, F. H.	Greenock
1897	Wilkinson, G. .. .. (*Past President* 1912)	Harrogate

Date of Election.		
1914	Wilkinson, H.	Radcliffe
1903	Wilkinson, J.	Hull Tramways
1895	Wilmshurst, T. P. (*Past Pres.* 1904)	Derby
1907	Wilson, W. H.	Sleaford
1911	Wishart, J. A.	Motherwell
1913	Wood, W. J. H.	Bolton
1906	Woodman, L. W. ..	Dover
1897 M 1902	Wyld, W. (*Past Member of Council* 1916)	Hampstead
A 1896 M 1905	Yeaman, C. H.	Stoke-on-Trent

HON. MEMBERS.

M 1898 1905	Chamen, W. A. (*Past Pres.*, 1901)	Cardiff
M 1896 1903	Holmes, A. B. (*Past Mem. of Council* 1898)	Liverpool
M 1895 1916	Mountain, A. B., (*Past Hon. Sec.* 1896, *Past Pres.* 1900)	Huddersfield
M 1895 1911	Rider, J. H. (*Past Hon. Treas.* 1900, *Past Pres.* 1901–2)	London
M 1898 1913	Shawfield, C. E. C. (*Past Pres.* 1912–13)	Wolverhampton
M 1906 1909	Snell, Sir J. F. C. (*Past Pres.* 1902-3)	London
M 1895 1910	Wordingham, C. H. .. (*Past President* 1898)	London

ASSOCIATE MEMBERS.

CHIEF ASSISTANT ENGINEERS

1912	Hudson, J. Barcroft ..	Bootle
1905	Lamb, C.	Dundee
1907	Ratcliff, H. A.	Manchester
1910	Yorke, W.	Sunderland

ASSOCIATES.

ASSISTANT ENGINEERS.

Date of Election.		
1903	Boyce, J.	Todmorden
1911	Bush, V. F.	Redditch
1901	Cairns, R.	Glasgow
1902	Channon, A. S.	Grimsby
1903	Day, S. E.	Bury St. Edmunds
1910	Dent, J. H.	Loughborough
1906	Douglas-Arden, G... ..	Derby
1904	Fairchild, J. C.	St. Annes-on-Sea
1915	Farndon, F.	West Ham
1899	Gilbert, A. C.	Edinburgh
1911	Hooper, W. P.	Dewsbury
1901	Howell, A.	Hornsey, N.
1904	James, E. W.	Hounslow, W.
1902	Jones, S. Derwen	Batley
1909	Lunn, E.	Huddersfield
1897	May, H. S.	London
1912	McDonnell, E. C.	Bootle
1902	Millington, W. G.	Peterborough
1899	Milton, C. O.	Maidenhead
1903	Nixon, A. T.	Sheffield
1902	Ogden, F. L.	Oldham
1896	Philpott, G. J.	Brighton
1904	Rolling, B. I.	Glasgow
1911	Saxton, C.	Bradford
1902	Thomson, J.	Leith
1898	Turner, J. W.	Huddersfield
1902	Young, W.	Stepney, E.

SUMMARY.

Committees.	Members	168
Engineers.	„	170
„	Hon. Members	7
Assistants.	Associate Members	4
„	Associates	27
		376

PUBLICATIONS

OF THE

Incorporated Municipal Electrical Association.

Author.	Title.	Date.
ACLAND, R. L.	Extension of Electricity Supply to outlying districts	1907
ANDREWS, L.	The Distribution of Electricity in Scattered Areas	1900
AYTON, F.	Cheapening of the Cost of Mains and Services	1910
	Means for Securing Reliability and Maintaining Continuity of Supply	1912
	The Use of Electric Vehicles in Municipal Service	1915
BARNARD, A. S.	Electricity Supply at 220 Volts.	1896
	High Tension Continuous Current Systems	1902
BAYNES. S. W.	Steam Turbines	1906
BEAUCHAMP, J. W.	Modern Wiring Practice	1911
BISHOP, H. COLLINGS	Means for Stimulating a Demand for Electrical Energy	1900
	The Commercial Development of Electricity Undertakings	1906
	Notes on the Commercial Progress of Electricity Undertakings	1910
BLACKMAN, A. S.	Steam Turbines from the User's Point of View	1909
BLACKMAN, A. S. AND ROLES, T.	The Practical Result of the Point Five Tariff	1915
BLAIKIE, J. R.	Distributing Systems	1897
	Switchboard Apparatus	1898
BLAKEWAY, COUNCILLOR.	The Financial Possibilities of Municipal Electrical Undertakings	1904
BOOT, H. L. P.	Street Lighting by Electricity	1897
	Method of Reducing Light and Load Losses	1900
	The Management and Working of Boilers	1903
BOWDEN, J. HORACE	The Standardization of Tariffs	1914
BREMNER, ASHTON	Extensions to existing Electricity Supply Stations by means of Mixed Pressure Turbines	1910
BURNETT, H. P.	The Costs of Electrical Supply and their Relation to Scales of Charges	1907
BUSH, VALENTINE F.	The Motor Meter as applied to the Measurement of Single Phase Alternating Current	1911
CARR, R. M.	Internal Combustion Engines in Power Stations	1911

Author.	Title.	Date.
Chamen, W. A.	Presidential Address	1901
	The Possibilities of Future Economies in Electrical Illumination	1903
Chattock, R. A.	Coal and Ash Conveying Gear	1901
	Presidential Address	1914
Christie, J.	Presidential Address	1911
	Air Filtration	1913
Clothier, T. D.	Electric Lighting Mains	1899
Couzens, H. W.	Alternating Current Stations and High Voltage Lamps	1896
	Prepayment Meters	1897
Cramb, A. C.	Commercial Advancement of Electrical Supply	1910
	Presidential Address	1916
Cridge, A. J.	The Organisation and Management of a Central Station Meter Department	1904
	Some Notes on Alternating Current Distribution	1907
Day, Arthur A.	The Correct Type of Engine for Large Generating Stations	1902
Downe, R. S.	Boiler House Economies	1904
Edgcome, J. E.	The Arrangement of Steam and other Pipes, and their Fittings	1899
	Presidential Address	1906
Ellis, H. S.	The Generation of Electricity on a Small Scale, or Bulk Supply	1916
Fedden, S. E.	Street Lighting by Electricity	1897
	Steam Turbines	1902
	The Commercial Development of Electricity Undertakings	1906
	Presidential Address	1907
	The Design and Operation of Modern Boiler House Plant	1914
Fell, A. L. C.	Braking Apparatus for Electric Cars	1901
Ferranti, S. Z. de	Prime Movers for Electric Power	1913
Gibbings, A. H.	Extensions to Outlying Districts	1896
	Municipal Aids to Wiring	1897
	Presidential Address	1898
Harris, G. M.	Electricity Works for Small Towns	1900
Hesford, Councillor.	The Management of Electricity Undertakings	1898
Hesketh & Rider.	Combined Electric Lighting and Traction plants	1896
Hewitt, F. W.	Fuses	1903
Highfield, J. S.	Refuse Destructors in Combination with Electric Power Stations	1901
Hoadley, E. E	Street Lighting	1905
	The influence of metallic filament lamps on the Electrical industry and on Street Lighting	1909

Author.	Title.	Date.
HODGSON, COUNCILLOR.	The Supply of Electricity in Industrial Areas from a Municipal Point of View	1905
HOLLINGSWORTH, E. M.	Modern Cable Systems - - -	1909
HOLMES, H. H.	Electric Cooking Apparatus- - -	1912
HOWARD, H. L.	Internal Combustion Engines in Power Stations - - - - - -	1911
HOWARD, H.	Steam Turbines : Their Efficiency compared with Reciprocating Engines -	1904
JECKELL, J. A.	Cable Specifications and Tests - -	1896
	Distributing Systems - - - -	1897
	Steam Using Plant - - - -	1898
	The Financial Improvement of Electricity Supply Works - - -	1903
KERR, W. T.	The Application of Electricity to Agriculture - - - - -	1916
KILGOUR, H.	Notes on Costs and Tariffs for Electric Supply - - - - -	1905
LACKIE, W. W.	Presidential Address - - - -	1910
	Boiler-House Design and Operation -	1916
LE ROSSIGNOL, A. E.	Impressions of Present American Tramway Practice - - - -	1900
	Electric Traction as Applied to the Newcastle Tramways - - -	1903
LEESE, COUNCILLOR H.	Electricity Supply viewed from the Municipal Committee's Standpoint -	1911
LONG, F. M.	A Cooking Load from the Supply Station point of view. - - -	1912
LUNN, E.	Notes on Condensing and Water Cooling Plant - - - - -	1906
LUNN & THOMPSON.	Notes on the Performances of Single Phase Motors - - - - -	1899
MACLAY, BAILIE.	Appropriation of Profits and Repayments of Loans - - -	1898
	Do. do. do. - - - -	1899
	Notes on Street Lighting - -	1901
MCCOURT, R.	The Value of Photometry in Central Station Practice - - - -	1907
MOUNTAIN, A. B.	Electricity Works Records - - -	1896
	The Municipalisation of the Telephone -	1899
	Presidential Address - -	1900
	Extensions to Outlying Areas - -	1905
MURRAY, J. R. CAMPBELL	Steam Power Generation. The Advantages of Mechanical Draft - -	1911
NEWINGTON, F. A.	Presidential Address - - - -	1905
	Exhaust Steam Turbines and Condensing Plant - - - - -	1910

Author.	Title.	Date.
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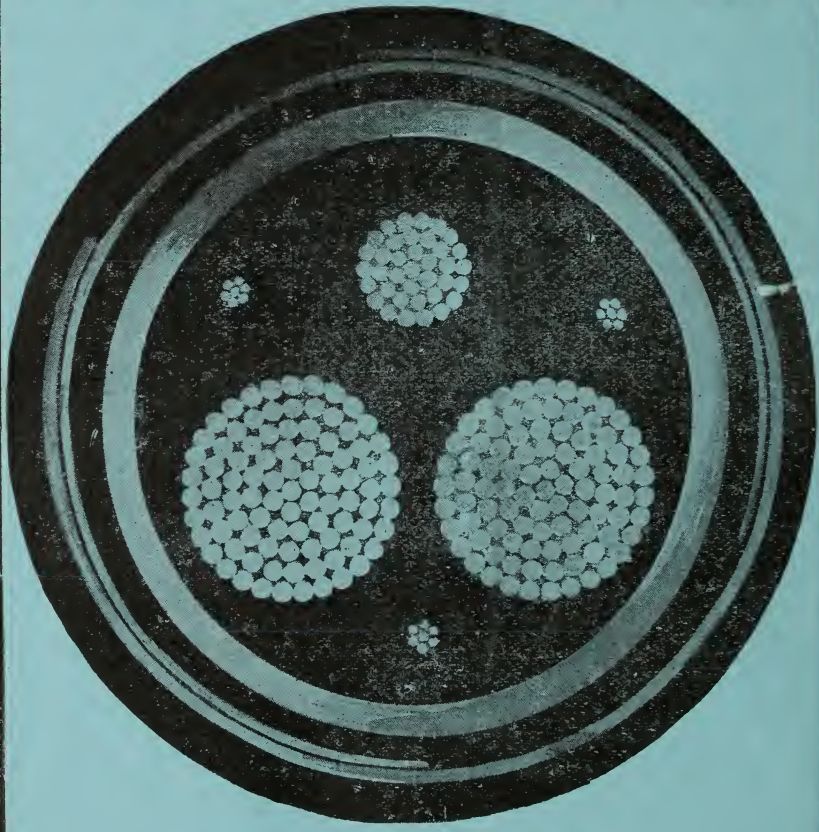

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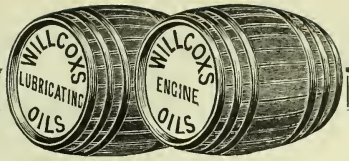

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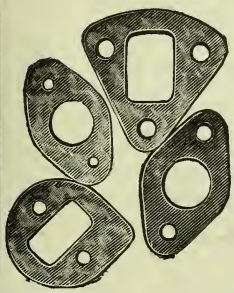

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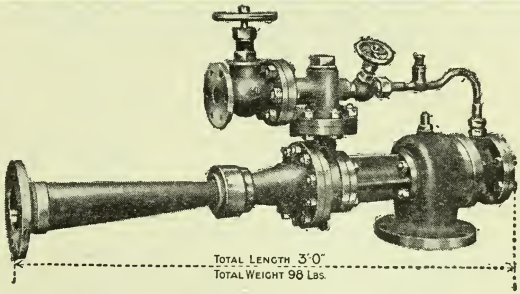

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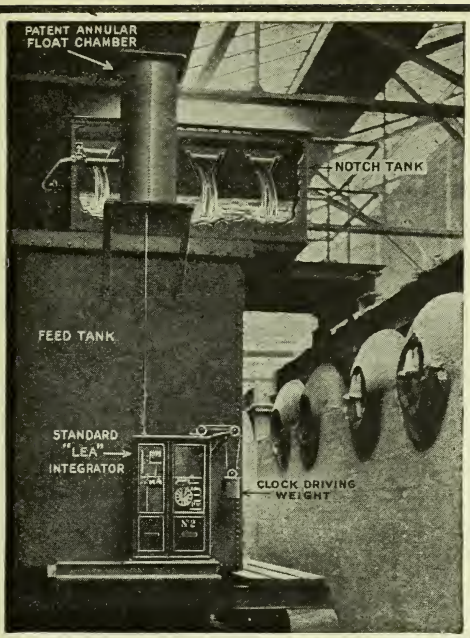

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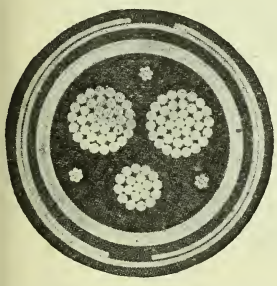

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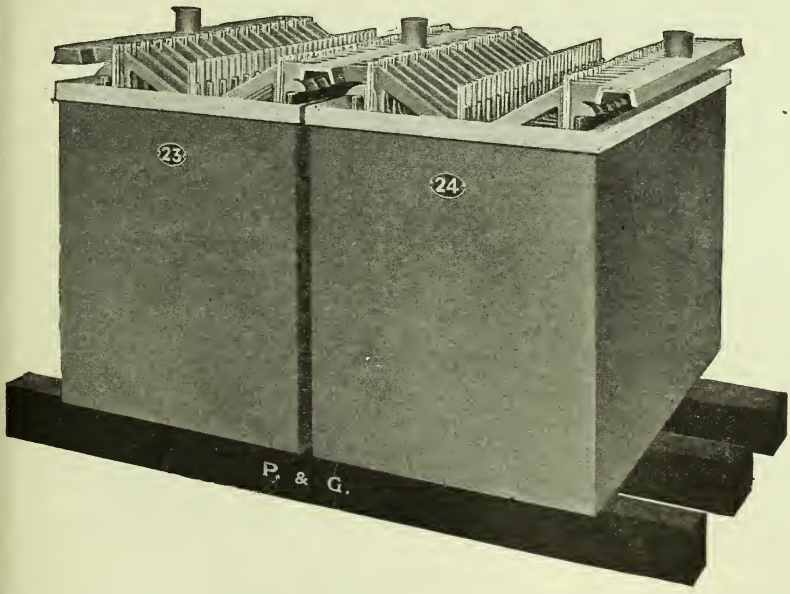

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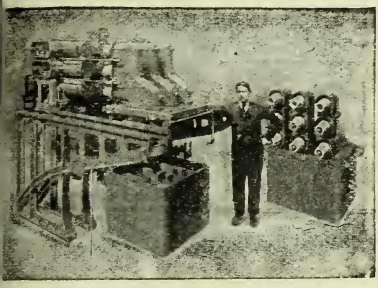

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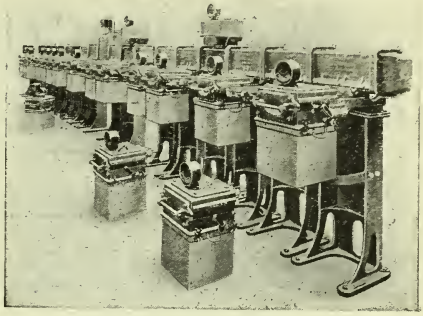

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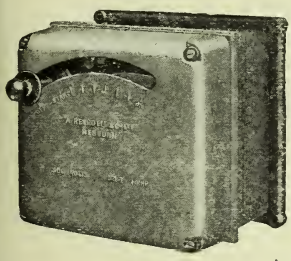

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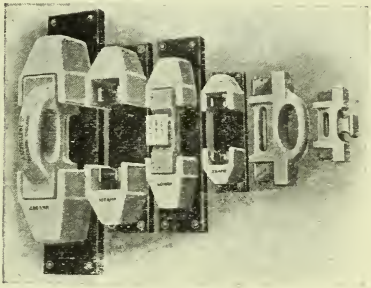

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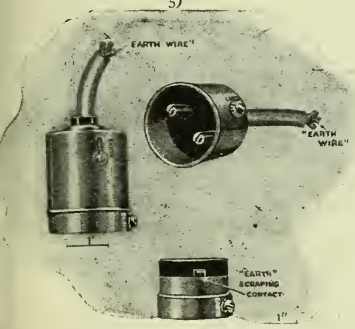

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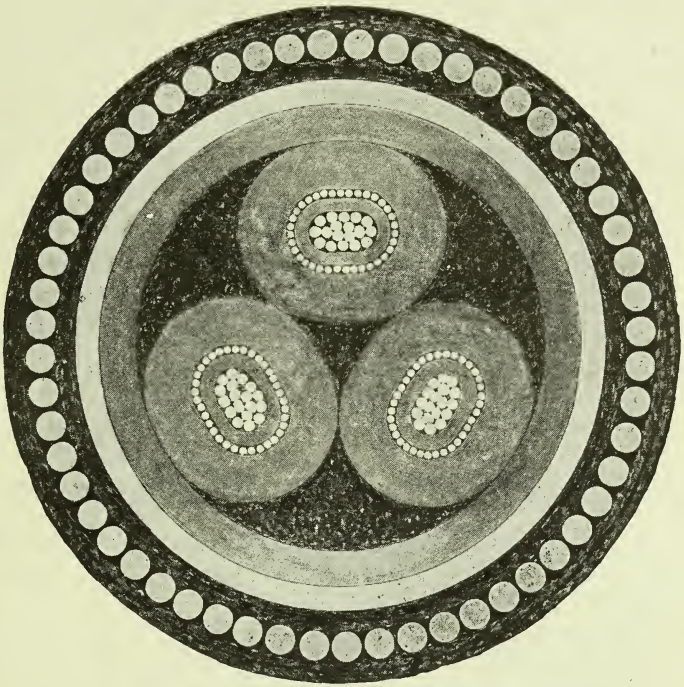

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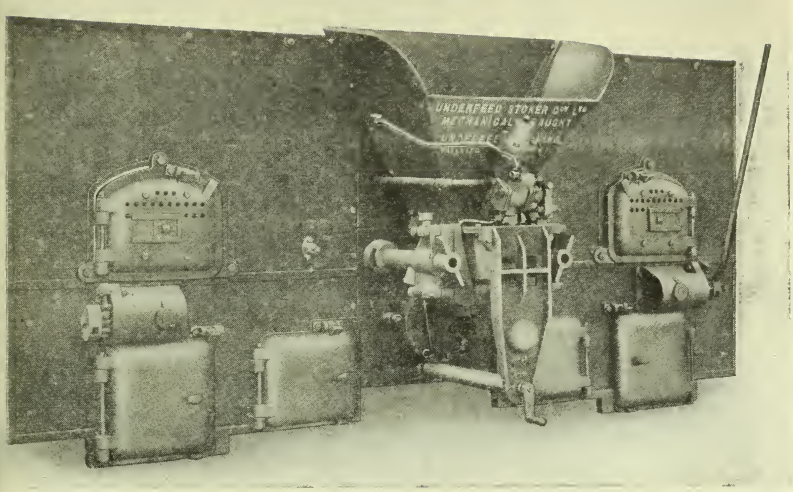
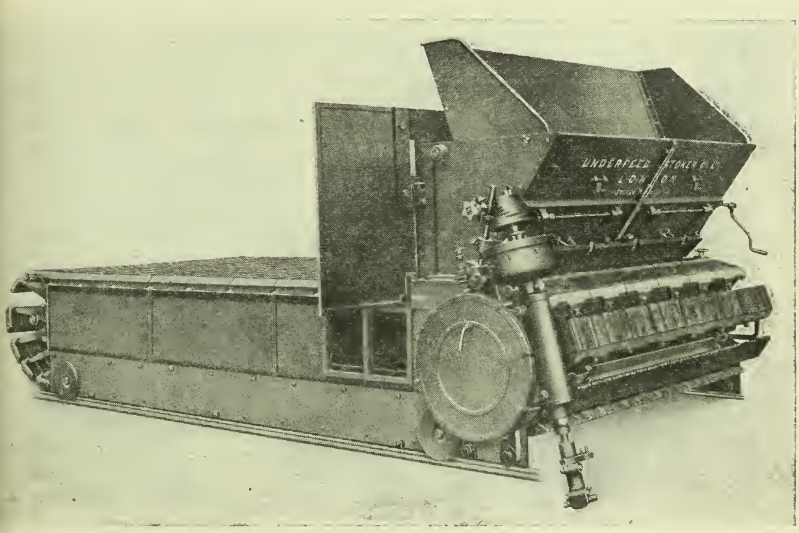


Impelled Draught, E Type.



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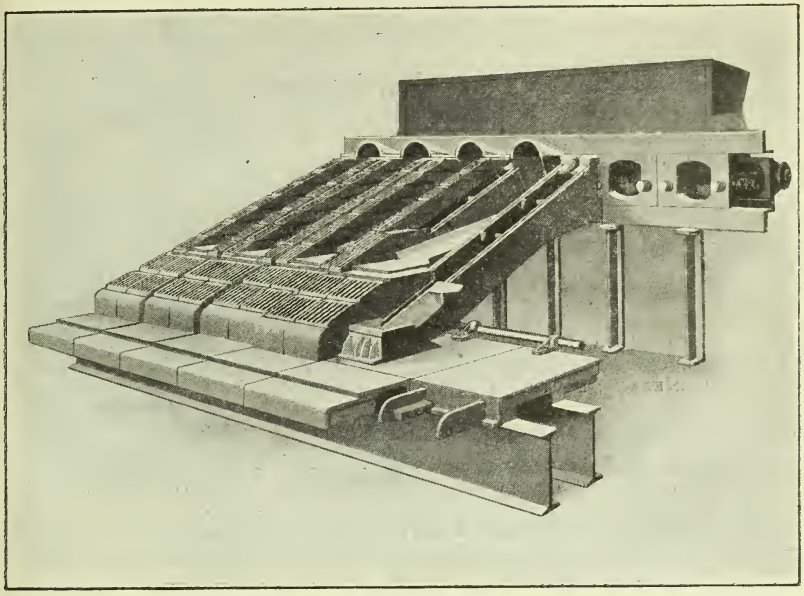
ERITH-RILEY STOKER



Furnace view, 6-retort size, partly erected.

All sizes, from 3 to 30 retorts per boiler, in use.

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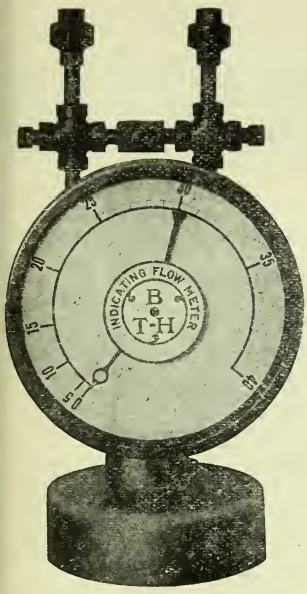

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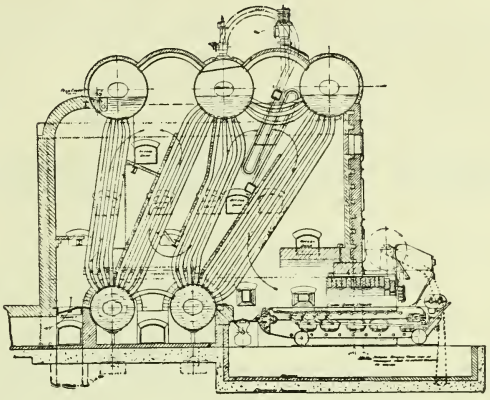
THE STIRLING BOILER.



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Edinburgh Corporation	11	,,	,,	,,	,,	61,972	,,
Fulham Corporation	6	,,	,,	,,	,,	24,300	,,
Glasgow Corporation	4	,,	,,	,,	,,	24,976	,,
Hammersmith Corporation	3	,,	,,	,,	,,	18,609	,,
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L.C.C. Tramways	24	,,	,,	,,	,,	81,720	,,
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THE STIRLING BOILER Co., Ltd.

54, Victoria Street, Westminster, S.W.

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STATIONARY & PORTABLE FOR ALL PURPOSES:

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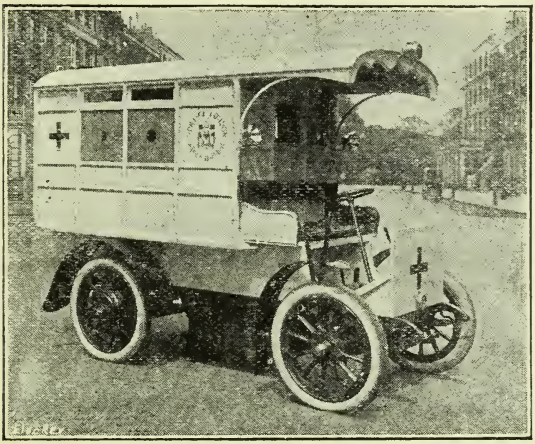

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Cheap Steam

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The "Bennis" Sprinkler Stoker

A powerful and rapid steam raiser, and is a favourite where sudden demands on steam are frequent. It burns low grade fuels, slack, etc., without smoke and keeps clear, strong fires. It distributes the coal to the parts of the fire requiring it. It keeps down the fuel bill and increases boiler duty.

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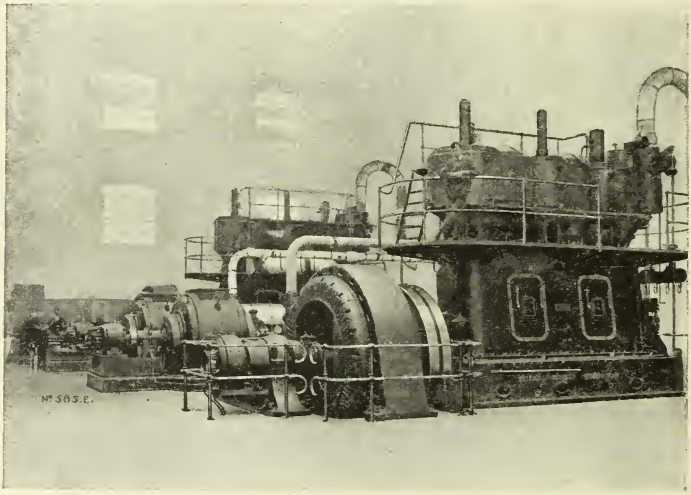

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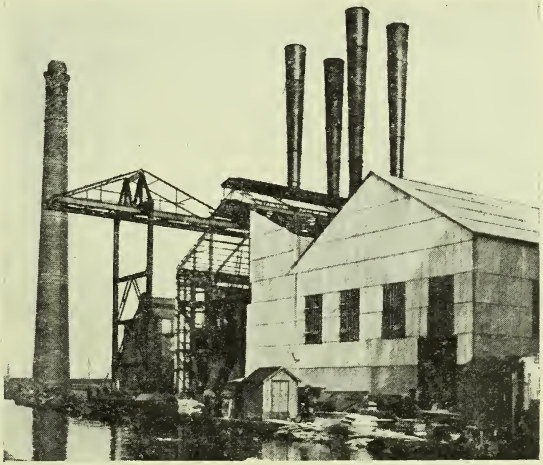

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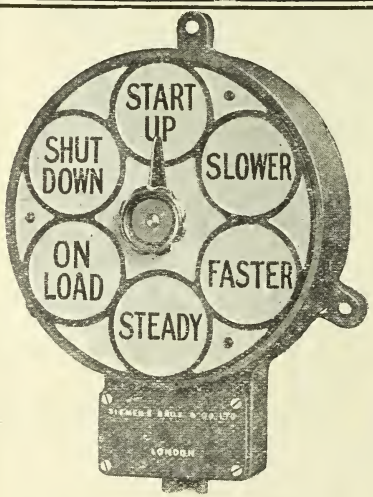

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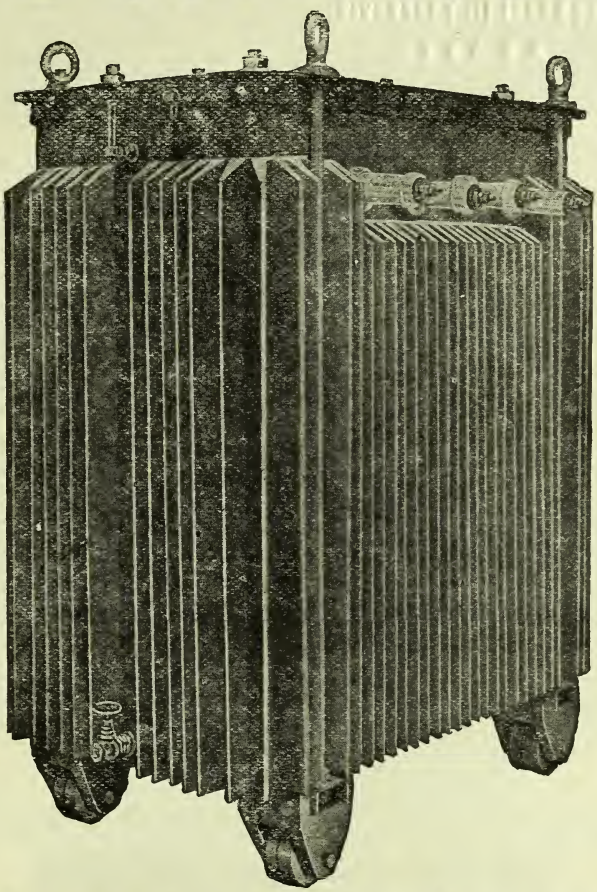

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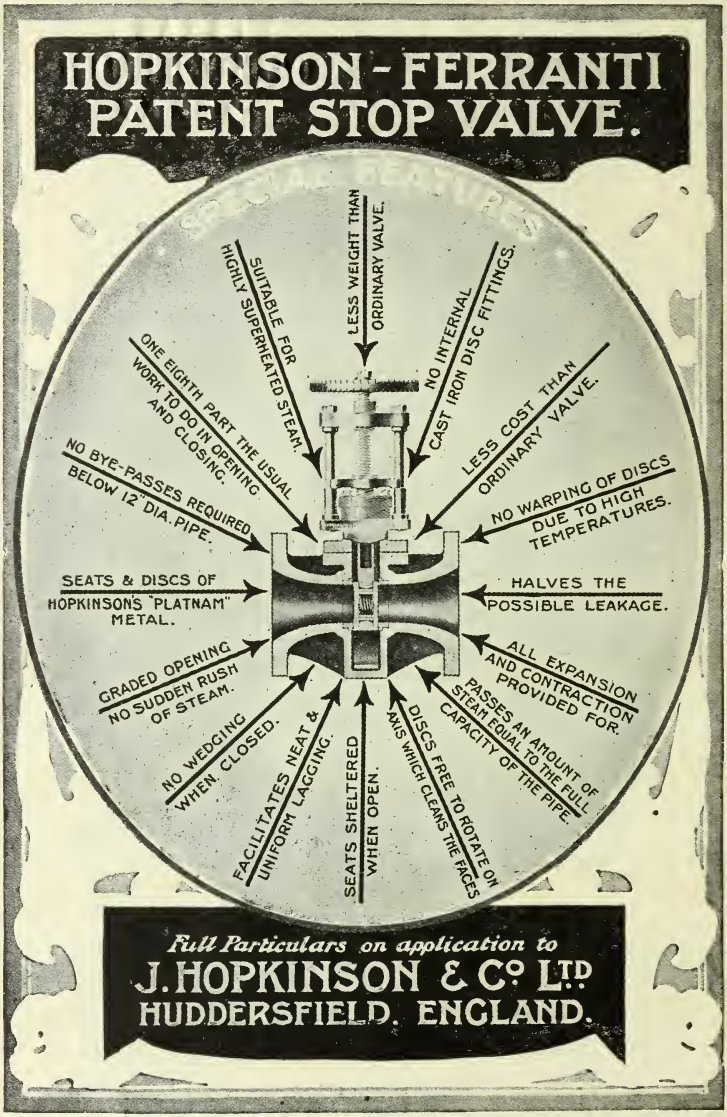
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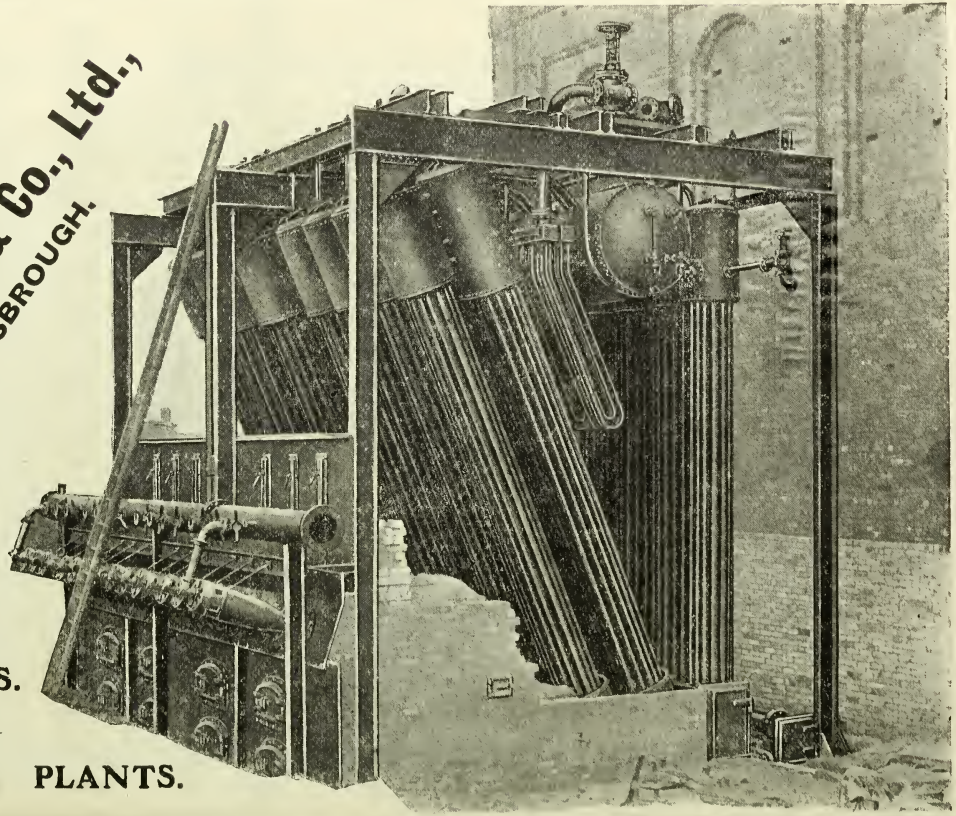

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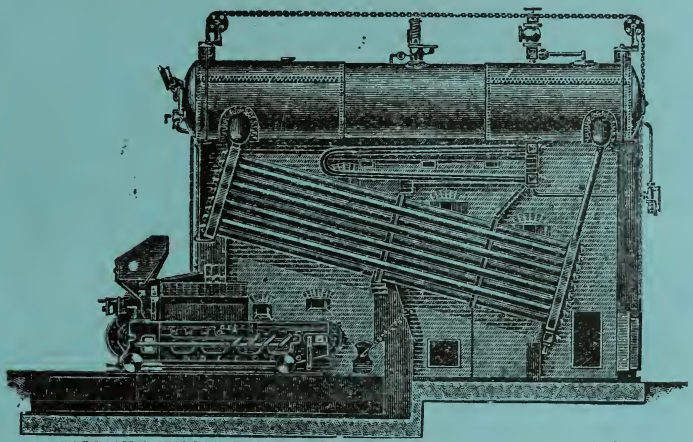

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